COMPARING ACTIVE AND DIDACTIC PEDAGOGIES

IN ELECTRONIC ENGINEERING

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Abstract

A passive, didactic style of teaching has historically been common for large cohort engineering teaching in Higher Education. By contrast active teaching designed to engage learners directly is predominantly carried out using smaller class sizes and is often used in workshops standardly involving some form of laboratory or practical element. This thesis evaluates the viability of employing an active rather than a passive teaching pedagogy for large engineering cohorts in higher education. It builds from the model of 'curiosity-based learning' as previously deployed by the author for small engineering groups and utilises the 'flipped classroom' model as the choice of active teaching pedagogy. However, rather than use changes in summative results to measure the effects as most flipped classroom models do, the research was designed to evaluate changes in learner's views in a number of categories. The categories tested included the importance of knowledge, skills and improvement, preferred learning and thinking style, self-esteem and self-efficacy.

Results indicate some support for an impact on a learner's desire to learn through improved curiosity and that a learner's preferred learning style can be affected although this may be slanted towards improved teaching practice rather than directly to learning style. There was no support for any changes to a learner's preferred thinking style but belief in a learner's current abilities (self-esteem) is partially supported. There is more support for a rise in a learner's self-efficacy such that they take more responsibility for their learning when exposed to active teaching – a key issue for budding engineers. However, there is evidence that active teaching must take place in the correct context and that learners are affected by the amount of additional study needed to prepare for lessons leading to a reluctance to engage fully in debate. Interestingly, there could be a flipside to this reluctance because the 'fear of contributing' to class discussion is seen to reduce.

Importantly, the study found that females showed more realism in their expectations of their own capabilities and willingness to take on more responsibility for their own learning when exposed to active teaching. There are also indications that students plan, organise and question more effectively when learning in an active teaching environment.

These results have implications for choice of pedagogical model and curricular design and indicate both the limitations and potentials of extending active teaching and learning from smaller to larger cohorts.

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1. Introduction

This chapter sets the context for the research carried out and introduces the types of teaching being compared, the background of the researcher, the target research population and justifies the research programme. It considers the focus of the research, setting it specifically into the context of Higher Education (HE) and explaining the background to the research in a number of areas. The first of these will be to outline the context of the research showing how it had developed from earlier research and defining the key terms that are used throughout the thesis. Research drivers from policy, quality and industry perspectives are considered with benefits and motivational factors taken into account followed by a discussion on other contextually related aspects of the research. Aims and research questions will be outlined followed by a review of the way in which this thesis is organised.

1.1 Research Focus

This thesis concentrates on the findings of a research programme studying how different teaching styles affect the learning and self-efficacy of engineering students. The setting for the research was an electronic engineering department of a Russell Group University (The University of York) but the output from the research is expected to be appropriate for engineering students in general and other programmes where an active teaching approach may improve learning. In particular, it compares different teaching styles and assesses whether there is a marked difference within the student cohorts, over a short period of time, through the adoption of either a didactic style of teaching or an active style of teaching. The students taking part in the research were successive cohorts of first year undergraduates and one year taught masters students, separated by their year of entry. The first-year students were chosen for two main reasons; a) they were new to HE and b) they would be starting a brand-new undergraduate programme and studying them during their first year could help in later longitudinal outcomes research. Whilst not initially a direct component of this study, after further theoretical review (see Section 2.3), overall longer-term goals such as differences in the way males and females approach learning in engineering contexts were considered as they might provide even further insight into teaching approaches and engagement of more females within engineering.

The taught MSc students studied in this research programme were in a similar position to the first-year students in that the vast majority of them were new to the United Kingdom (UK) HE education system and they potentially provide an additional perspective on the teaching style that they have experienced here. Also, they are typically comprised of a more even spread of gender than the typically male dominated first year undergraduate engineering cohorts and could potentially provide a more balanced output in terms of male versus female responses.

The study was carried out over two years and allowed comparisons to be made between undergraduate/postgraduate students in two intakes where one intake was subjected to didactic (passive) teaching whilst the second was subjected to active teaching. It is important to understand that the teaching changes were only applied to one component (module) of the student's overall course within the data collection period. The researcher was the lecturer delivering the module where the teaching approach was deliberately changed, all other modules given by different lecturers in the data collection period were taught in the same way to both cohorts. This action-based research used pre/post teaching surveys, administered to both cohorts in both intakes, to provide inter-cohort data as well as allow for intra-cohort comparison of the effect of pedagogy differences.

1.2 Background

With his newly adopted role as an engineering teacher in HE and having 31 years of industrial engineering experience, the researcher was interested to understand how engineering students learn. Would an engineering student learn better through formal lectures (mainly passive learning) or through an active teaching approach that encouraged dialogue, participation and engagement within the learning environment? Also, the researcher wondered whether an active teaching approach at an early stage in a student's higher education experience would spark a desire within the student to take more responsibility for their own learning throughout their higher education. Initial reviews of the relevant literature identified limited research into active teaching and learning approaches within a HE, engineering context (Toto and Nguyen, 2009; Zappe et al., 2009, Bishop and Verleger, 2013). However, it did identify some research into this approach using small cohorts of students (Khun, 2005; Binson, 2009) where small is defined as 30 students or fewer. The researcher's early attempts to look at the issue for engineering students (Jackson and Ward, 2012) followed a small first year cohort but left untouched the issue of large cohort teaching and learning i.e. greater than 30 students in a cohort.

1.2.1 Research Context

Jackson and Ward's (2012) research adopted a 'Curiosity Based Learning' (CBL) model as used in previously identified studies (Khun, 2005; Binson, 2009) but for electronic engineering students. It did not explore other styles or approaches to active teaching and learning such as dialogic teaching, 'flipped classroom' etc. but some studies of the flipped classroom approach have been carried out in colleges and further education institutions for science, technology, engineering and mathematics (STEM) subjects (Bidwell, 2014), in engineering design (Toto and Nguyen, 2009) and in architectural engineering (Zappe et al., 2009). Bishop and Verleger (2013) looked at research into this area and concluded there was indeed some evidence that a flipped classroom approach encouraged deep level learning as well as a tendency for students to be better organised and become more self-reliant.

The researcher found little evidence of using such approaches in large cohort teaching, especially in the engineering disciplines, although within the scientific teaching arena (psychology) there was some evidence that using a dialogic approach was effective, even in larger cohorts (Alexander, 2008 and 2013). These findings from the literature identified a gap in active teaching methods for engineering students and especially the use of a flipped classroom technique in large cohorts that investigated student skills development rather than summative outcomes. This encouraged the researcher to consider the proposed research to be useful, valid and achievable for providing an original contribution to expand pedagogical knowledge in this area. The output from the research will be used to inform teaching practice within the engineering education arena and develop more effective teaching approaches that encourage deeper learning (Light et al., 2009). It is also intended to inform future research direction in the education of engineering students.

The thesis contains a number of acronyms and abbreviations and it will be useful for the reader to understand them from the start. Table 1.1 defines the specific terms used within this thesis that could be confusing and Table 1.2 lists the abbreviations/acronyms used to enable clarity and ensure consistency of terminology throughout the thesis.

Table 1.1 - Definitions

A didactic teaching approach is defined as one where the learners are expected to adopt a passive role and listen to the teacher, only asking questions for points of clarity;

Active teaching is defined as any teaching approach that encourages interaction, dialogue, feedback and discussion within student cohorts, between student groups and between students and their teachers. Students are encouraged to ask questions and discuss answers/points made in an effort to provide a greater and deeper context to their learning;

Curiosity Based Learning (CBL) is where the teacher uses a series of micro-lectures and encourages both intra and inter-group discussion of the micro lecture.

Cohort is defined as a group of students studying the same course who started their course of study at the same time;

Transformative learning is defined as a process of "perspective transformation that has three dimensions: psychological (changed understanding of the self), convictional (revised belief systems), and behavioural (changed lifestyle)" (Mezirow, 1978, p. 101);

Flipped Classroom (Tucker, 2012) is defined as a process whereby students are expected to read appropriate learning materials prior to arriving at a given teaching session. The teacher acts as a facilitator in an attempt to provide insights and self-realisation that may lead to a transformative outcome in the students (Mezirow, 2003);

Dialogic teaching (Alexander 2008; 2013) is defined as a process where the lecturer adopts the role of chairman, ensuring discussion is focussed on appropriate learning outcomes but that students arrive at the outcomes through dialogue;

Self-esteem typically denotes more general feelings of worth to oneself (see Maslow, 1943; Rogers, 1951 etc.) but in this research is used only in relation to the academic domain. It is thus defined as a student's current perception of their ability to actually do a task or carry out an activity at that moment of time;

Self-efficacy (Bandura, 1977) is defined as an individual's belief in or perception of their ability to succeed; a judgement of confidence in ability to succeed at a given task, activity or endeavour in the future. For this research, self-efficacy is limited to factors used to measure relative changes after exposure to specific styles of teaching.

Push factors are defined as aspects affecting the inputs to educational processes; and

Pull factors are defined as aspects affecting a learner's outcomes or prospects.

Table 1.2 – Glossary of Terms used within this thesis

Abbreviation	Expansion
ANOVA	Analysis of Variance
AR	Abstract Random
AS	Abstract Sequential
CBL	Curiosity Based Learning
CDIO	Conceive, Design, Implement and Operate
CPD	Continuous Professional Development
CR	Concrete Random
CS	Concrete Sequential
DfE	Department for Education
EdD	Professional doctorate in Education.
EU	European Union
H0	Null Hypothesis
H1-5	Hypothesis 1 to 5 as the alternative hypothesis or specific question
HEA	Higher Education Academy
HE(I)	Higher Education (Institute)
IET	The Institution of Engineering and Technology
LLL	Life Long Learning
Pre	Pre-Teaching
Post	Post Teaching
QAA	Quality Assurance Authority
RAE	Royal Academy of Engineering
RDC(n)	Research Degree Committee (Paper number)
RQ	Research Question
RVS	Relationships, Variety and Synergy
SALEIE	Strategic ALignment of Electrical and Information Engineering (in European Higher Education Institutions)
SE	Self-Efficacy
SPSS	Statistical Package for Social Science
STEM	Science, Technology, Engineering and Maths
TEF	Teaching Excellence Framework
UCISA	The Universities and Colleges Information Systems Association
UK	United Kingdom
VAK(T)	Visual, Auditory, Kinaesthetic (Tactile)

1.2.2 Research Drivers

Current pedagogical thinking indicates the need for students to be engaged in their learning (Cartwright and Hardie, 2012; Ball, 2013) and to be more critical in their thinking (Kadir, 2007) if they are to achieve a changed perspective and improve their overall employability prospects. When trying to improve their own capabilities, the learner is also affected by personal issues including cultural background (van Berkel, 2010) and motivation (Dewey and Bentley, 1949; Rumble, 1986; Walkin, 2000; Laurillard, 2002).

Industry skills requirements of engineering graduates are much wider than those traditionally developed within the engineering education arena (The Institution of Engineering and Technology, 2016; Royal Academy of Engineering, 2007, 2016). Theory is required by students if they are to understand underlying principles but practical application of such theories through workshops, laboratory activities, discussion etc. are key additions for industry (e.g. The Institution of Engineering and Technology – IET, 2016). This indicates that HE providers need to concentrate on a more experiential approach if they are to satisfy industry needs for graduate employees. The skills development agenda outlined by government, professional bodies and industry have become key drivers for teaching and learning in UK HE (RAE, 2007, 2016; QAA, 2016; The IET, 2016). Other drivers include the pressure on HE institutions to improve their National Student Survey results and HE positional ratings in order to attract better quality students and to comply with teaching excellence framework policy (DfE, 2016; DfE, 2017). This may be affected by the teaching and learning experiences of students and their learning environment (UCISA, 2016) thus more effective teaching approaches and resources should lead to more motivated learners. It is important to understand student motivation in order to improve student outcomes, improve institutional ratings and HE teaching quality (Pollard et al., 2013). Skills development and employability agendas (Higher Education Academy, 2007) could be addressed in HE institutions through different teaching approaches. The output of this research is expected to inform how adopting specific pedagogical approaches can lead to a positive impact on an individual's self-efficacy. This in turn indicates there is likely to be an impact on future teaching resources, course layout and curriculum design.

1.2.3 Motivational factors

One of the issues affecting students lies within their personal motivation to achieve (Biggs, 1985), which is arguably linked to their self-esteem and their self-efficacy (Arshad et al., 2015). Motivational factors for students to address their educational needs are in part comprised of a student’s belief in their own current capabilities (self-esteem) which in turn may be affected by specific teaching approaches (Ojunugwa et al., 2015). Understanding the motivators for students to take more responsibility for their learning is a key objective of the research carried out. Student motivation can be short term, long term, externally or internally generated and might be focussed on pure learning or on additional personal benefits. Factors such as learning style, thinking style, self-esteem and self-efficacy (Schunk, 2012) consistently appear in educational research (not just engineering education research) and form the major component of this research. Whilst there is much debate on the meaning of learning and teaching styles, gathering data on the above motivational factors helps to evaluate the effectiveness of the teaching approach for the researched cohorts and for engineering curriculum design. This in turn helps us to evaluate our current curricular content and delivery and helps us to evaluate the resultant impact upon student motivation in terms of the student’s willingness to take responsibility for their own learning.

The research reported in this thesis has been motivated by many of the above factors in terms of improving the researchers’ teaching effectiveness and furthering his personal development through a better understanding of student motivators and pedagogical practice. It was considered that by carrying out such an in-depth piece of action research i.e. investigating the effect of specific pedagogical approaches on student learning, a more informed approach could be taken to designing existing courses of engineering education. One aspect of current student motivation is of concern to the researcher, that of student attendance to lectures, workshops etc. Designing courses of study that would be more effective in delivering the stated learning outcomes and more attractive to students who attend might be a way of addressing this trend and has certainly been a key motivator in carrying out the research reported here.

1.2.4 Other contextual aspects

There are a number of other aspects that need to be considered;

The impact of teachers who have high levels of self-efficacy rather than those who do not may have a bearing on the overall student journey. The researcher was aware of other teachers that the target population was exposed to within the data collection period. Before the research began it was confirmed that no changes to the relevant teaching staff were planned during the two data collection periods and that the pedagogical approach would only be altered by the researcher himself whilst delivering the learning to all student cohorts. By keeping a consistent approach everywhere except in the target research module, levels of teaching self-efficacy were not expected to have had a significant impact on the research outcomes. However, by adopting a passive teaching style during the first data collection period the researcher has taken himself out of his normal pedagogical approach and thus could have been less effective as a teacher despite ensuring all learning outcomes were covered during both passive and active teaching periods.

Each of the studied cohorts was different (separated by their year of entry) and thus there were not only personal (internal) differences in individuals but also some differences in the external influences affecting the student cohorts. Issues such as:

Environmental issues have been addressed through the use of the same lecture venues;

Teaching materials and resources are identical even though they are delivered in different ways;

Class size is similar due to institutional intake procedures;

Educational background may be different due to specific cohort make up. The main issue being one cohort of undergraduates and one of postgraduates studied at each data collection point. However, this was considered to be an equally weighted random factor as all were experiencing HE at an English university for the first time. Data on educational background was gathered despite it being considered to be similar for all cohorts to allow for this factor to be included where deeper analysis was required to explain a given result;

Gender proportion was different due to specific cohort make up but was measured and taken into account for both cohorts during the analysis;

Cultural aspects were not influenced by the researcher and were dependent upon the random nature of the cohort make-up thus no effect was anticipated although data was gathered to be was used where there was any indication of cultural influence.

Use of dialogic techniques and team-working on students' propensity to learn was an unknown factor as some students already had experience of these and others did not. These two aspects were considered to be part of the random nature of cohort make up and were treated as similar in the research carried out.

The collaborative aspect of human nature is a factor that changed with each cohort but the same information and encouragement was given at all times to each student cohort thus reducing to a minimum any potential impact on this research.

Group dynamics between cohorts of the same type were not noticeably different. In undergraduate cohorts (circa 130 students in each) had a similar proportion of males to females and similar age and ethnic background profiles were exhibited. In postgraduate cohorts (circa 50 students in each) the same group make up was evident – mainly Chinese ethnicity, equal numbers of males and females and the proportion of slightly older students being similar. A full breakdown of group dynamics can be seen in the findings, Chapter 4.

1.3 Initial aims for this research programme

Stemming from the researcher's interest in improving the effectiveness of his teaching practice, the research set out to measure the impact of an active teaching approach compared to a didactic teaching approach in electronic engineering students. The output is intended to inform the design of teaching materials for future courses both at York and in the wider engineering education community as well as identifying further areas for research.

Initial research questions:

1) *The flipped classroom – does this dialogic and active teaching approach lead to a change in a learner's preferred learning or thinking style compared to a didactic, passive teaching approach?*
2) *Does a flipped classroom active approach enable students to be more confident in taking responsibility for their own learning and achievement compared to a didactic, passive teaching approach?*

The research questions above have developed from a loose interpretation of 'active teaching approaches' to one of concentrating on the flipped classroom approach. This was due to three main influences;

i. further literature review leading the researcher to a more easily comparable approach (see Chapter 2);
ii. being more realistic about what could be done in the time; and
iii. applying a modicum of common sense to final research output requirements by reducing the length of the quantitative data research instrument.

The overall research was carried out to understand student motivation bearing in mind the very practical issues faced when undertaking a degree. The ability to properly focus teaching and to help channel students' learning more effectively can be a benefit to both students and teachers. If, at the same time, the teaching approach could be better positioned to address some of the external pressures of the skills agenda, then engineering education could be designed more efficiently and thus become more effective.

If the teaching approach can influence the confidence of students in approaching tasks/activities whilst at university then it is likely that this confidence will, at least in part, be carried through into their working lives. Small cohort studies have been carried out using flipped classroom teaching and generated positive results compared to traditional or other blended learning approaches (Khun, 2005; Binson, 2009; Jackson and Ward, 2012). However, there was an identified gap in the academic literature regarding comparisons of flipped versus traditional teaching approaches for large cohorts and, when taken in the HE context, there was an opportunity to look into flipped approaches for engineering student cohorts. The question as to whether the use of a flipped classroom approach in large class settings actually encourages development of effective deep learning and higher self-reliance is addressed in this research programme.

The research was initially carried out in an attempt to answer the following overarching questions that are developed further in Chapter 3, Methodology:

1. Are there any merits to using active learning versus passive learning in our approach to teaching engineering;
2. Is a flipped classroom approach suitable for large (engineering) cohorts;
3. Does active teaching enhance student learning in engineering subjects; and
4. Is there evidence that shows a change to pedagogical and scholarship approaches improves the educational offering to engineering students?

1.4 Organisation of the thesis

Chapter 2 provides the original literature review along with an updated review of relevant literature to add reasoned evidence that underpins changes where the original research focus was refined. The usefulness of learning or thinking styles in research is not clear, given that both are very subjective, and models that purport to measure them tend to identify a preference rather than a definite style that will be adopted by learners. Teachers adapt their pedagogy appropriately for different learning materials and learners adopt the appropriate learning style that best copes with that material, not necessarily their preferred style. Chapter 2 explores these aspects alongside other pedagogical drivers.

Chapter 3 provides a review of the methodology adopted and shows how that methodology was derived and modified throughout the duration of the research. There is a section that explores the ethical issues of the research and helps to assure readers of the sound ethical approach used throughout this research.

Chapters 4 and 5 provide the main findings of research from undergraduate and postgraduate cohorts where Chapter 4 presents the quantitative findings and Chapter 5 synthesises the main quantitative outputs and includes relevant qualitative findings from post teaching interviews with all student cohorts. The format of Chapter 4 includes a variety of tables, graphs and text, set out to help comparisons to be drawn. Some analytical commentary is provided within Chapter 4, further commentary is added where qualitative input is included in Chapter 5 and overall comparison of findings with literature is contained within Chapter 6.

Chapter 7 draws out the conclusions from this research and sets out recommendations for further research.

Finally, there are chapters containing a full reference listing and appropriate Appendices are included to support the analyses completed throughout this research. Extracts from data tables in Appendix 10 will be used within Chapter 4 – undergraduate and postgraduate quantitative findings.

2. Literature Review

2.1 Overview

This research developed from earlier research by Jackson and Ward (2012) aimed at developing students' willingness to take responsibility for their own learning and skills development (meta-learning) through encouraging their natural curiosity; building on findings from similar research by Khun (2005) and Binson (2009). Jackson and Ward's (2012) research recognised the lack of research into active teaching and learning approaches in the HE context (Toto and Nguyen, 2009; Zappe et al., 2009; Bishop and Verleger, 2013) and looked to stimulate the natural curiosity of students through a Curiosity Based Learning (CBL) teaching approach. The findings were mixed with results showing that other factors affected outcomes, such as students' willingness to engage in dialogue both within the team and between teams, their range of cultural backgrounds and their respective expectations of the teaching (Alexander, 2013). The research presented here attempts to clarify and expand on Jackson and Ward's (2012) research findings by adopting a 'flipped classroom' teaching approach in HE students using case studies that add focus to pre-set required reading (Tucker, 2012).

2.2 Background literature research findings

This section examines the literature surrounding the relative effectiveness of more traditional versus active teaching methods employed in HE today considering any key drivers that might influence learning outcomes and thus the teaching approach. Aspects were uncovered by this author in areas as diverse as policy for teaching and learning, theory related to active/passive teaching approaches, the impact on the learner from differing teaching approaches and learning that may affect a student's learning or thinking style.

2.2.1 Policy aspects

The emergence of the 'knowledge economy' may be due to recent government initiatives, driving policy within the HE environment that is intended to help develop skills within students that are both useful for the student and for industry (Ball, 2013). There are a number of pedagogical approaches that teachers can draw from running concurrently with these drivers and university policies that allow the teacher to use their own personal preferences and to be flexible in the way that learning outcomes are achieved (Sheppard, 2013). Cartwright and Hardie (2012) assert that HE institutions need to take account of their own teaching approaches in order to make better informed policy decisions. This consideration would need to encompass a wide range of approaches including how often and how large policy changes are, commercial sector skills requirements, suitability of teaching approaches used, any subject specific aspects in the institution and the visibility and availability of the information on these aspects.

HE institutions have to interpret government directives, the requirements of accreditation bodies and market forces, then have to create and/or adopt pedagogical approaches that reflect these requirements and the best interests of their students. This creates conflict in the management of HE institutions in that whilst they are not managed by government, they are regulated through the Quality Assurance Authority (QAA) and are driven more by multiple clients (government, QAA, industry etc.) who could impose financial and operational restrictions for failure to comply (QAA, 2016). HE institutions have a clear need to cope with policies that could affect programme and learning outcomes such that they are seen to be acceptable by all parties and yet still be achievable within the HEI. A recent publication by SALEIE, a European project (Strategic ALignment of Electrical and Information Engineering in European Higher Education institutions) looking into policy impact on programme creation, concluded that new programmes within HEIs should reflect that institution's ability to respond to skills development for employment needs (SALEIE, 2015). This was demonstrated previously through the implementation of policies driving lifelong learning (Wilson and Train, 2006), widening participation (Department for Business, Innovation and Skills and Willetts, 2012) and recently the Teaching Excellence Framework or TEF (DfE, 2016). Developed from a review of teaching performance indicators and policy drivers (Pollard et al, 2013), TEF was introduced by the Department of Education to "…**drive up standards of teaching** and give students **clear, understandable information** about where they are likely to receive the best teaching and outcomes." (DfE, 2017, p4). Industries that promote continuous professional development (CPD) within the workforce are likely to refer to the outcomes from TEF assessments or other emerging assessment methodologies (QAA, 2016; Royal Academy of Engineering, 2007, 2016) to recruit people to their workforce that enhance the capabilities of their companies. This may increase competitive pressures on HE institutions to deliver 'ready to work' graduates through focussed policy implementation and academic excellence in both teaching and research. This requirement may force HEIs to re-visit the need for specific learning outcomes to be achieved through the use of certain 'one size does not fit all' policies, and is likely to become a drain on institutional resources.

The requirements of the TEF in HE may not result in the 'excellent teaching' expected of such policy implementation as the pressures upon teacher performance rise exponentially to achieve a future where excellent teaching, however that may be measured, will be directly rewarded in some way (Royal Academy of Engineering, 2016). It remains to be seen whether the implementation of such policy drivers are reflected in student learning outcomes and overall levels of achievement. It should be noted that not all cohorts can or will achieve at the same level irrespective of the standard of teaching or directly appropriate policy implementation (Higher Education Academy, 2015).

The measure of teaching excellence should not affect the requirements of students, the level of demand for places at the HEI or impact on student achievement. These factors will remain key and could impact negatively upon a teacher's willingness to try out new approaches. Collini (2016) discusses development of such teaching quality measures in that they will result in league tables, with the link to student fees for HE funding becoming stronger, there will be a subsequent drive towards higher scores in the TEF to justify rises in HEI fees. Collini goes on to assert that such policies are likely to produce conformity rather than better quality teaching. These issues need to be considered within the ever-changing policy intentions announced by governments and prospective governments regarding student fees and HEI expectations thus they are likely to be fluid rather than static issues.

It would seem from the above that policy is a key driver, with many facets, that could impact upon how HEIs develop their pedagogies and any teaching approaches adopted. With the drive to produce more engineering graduates (RAE, 2007), it is important to identify the best teaching approaches for engineering students and to implement pedagogies that allow the freedom for teachers to adopt the most relevant approaches, informed by theory as well as practice, to address this issue.

2.2.2 Pedagogy Theory

There are many theories about teaching, learning and related environmental factors and student learning. Theorists such as Dewey from as early as 1949, Berne (1961), Mezirow (1978;2003), Kolb (1984), Dunn and Dunn (1984; 1990; 2000), Price (1984), Bandura (1977; 1994), Freire (1986), Pajares (1996), to Alexander in 2013 (to name but a few) have developed key theories in these areas. Some theorists looked at personal factors such as preparedness, attitude or state of mind and such personal factors tend to cross all of the teaching types described below.

2.2.2.1 Didactic Teaching

The theory underpinning didactic teaching arguably stems from the 1800-1900's when philosophers, such as Francis Bacon and John Locke, posited that all learning is gained through experience that can be tested and re-tested using empirical methods. An approach derived from Herbart (in Hergehahn, 2009) believes that teachers should identify what learners already know and then position why more learning is important by relating any new teaching materials to that knowledge. This focus on discovery and application as a systematic construct is delivered through a didactic approach using lectures, teaching learners ‘what’ to think, not necessarily ‘how’ to think, as well as giving them a repository of knowledge akin to a dictionary (Fry et al., 2003). However, it is closely aligned to one of the ways humans acquire knowledge outside of the taught environment through *a posteriori* or experiential knowledge outlined by Fieser (2008) and can thus easily be adopted by teachers as a ‘show and tell’ or ‘talk and chalk’ approach depending on the teacher’s own preference. Teaching preference is likely to be based on supportive, previous experiences affecting both teacher and student alike (Bandura, 1977, 1989; Olsen et al., 1996).

2.2.2.2 Auto-Didactic Teaching

Dewey and Bentley (1949) discussed motivational factors for learners within specific environmental and behavioural situations. Their concept indicated some form of transaction taking place between teachers and learners and that in any such transaction there was some ‘distance’ between teacher and learner dependent upon the environment (Rumble, 1986). Walkin (2000) and Laurillard (2002) discuss the uniqueness of individual learners denoting the unique attributes as ‘variables’ affecting a student’s preparedness, capability and willingness to learn. This could necessitate a different approach for individual students to help motivate them or encourage them to ‘travel the appropriate distance’. This might lead to further interactions between teachers and learners and thus a more interactive style of teaching could encourage students to be more independent and critically reflective in their learning (Gregory, 2002), arguably bridging the gap between didactic teaching and active teaching. Kirschner et al. (2006) agree that guided teaching and learning are more effective than less-guided and so take the view that didactic approaches or those that encourage learners to be auto-didactic (more independent learners) are better than the more modern approaches that use purely active teaching approaches at all times.

2.2.2.3 Active Teaching

Active teaching encourages students to solve their own gaps in knowledge by critically investigating a topic, spending more time outside of the classroom than is normally expected and potentially adding to a students’ workload (Lombardini et al., 2018). Bishop and Verleger (2013, Fig 2) propose a constructivist approach using problem solving and critical evaluation (listening, analysing, thinking and questioning). Learners construct a new way of thinking and learning through reflection rather than by memorising facts. New knowledge is embedded using an iterative and piecemeal approach until it fits their own understanding. The process of supporting learners as they grow, to a point where they can assimilate the required knowledge, is known as scaffolding and was originally conceived for learning activities in children (Wood, Bruner and Ross 1976; Vygotsky, 1978). However, adult learners are usually expected to understand and recognise their own starting point or their current levels of knowledge if they wish to benefit from the learning event; i.e. they are approaching their learning from an enquiring, open-minded perspective rather than as a student who comes into a class expecting to be given the facts.

Theorists such as Kolb (1984) and Schön (1991) felt that reflexive activity was appropriate to a learner's journey and this approach is still popular today. Other theorists (e.g. Friere, 1986; Bordieux, 2003) felt that the political background of the teacher was a major factor in the approach teachers adopted and thus the message that came across with the required learning would be biased in some way, pandering to political views and thus not relevant or desirable for the learner. Indeed, Friere (1996) was particularly disparaging about dialogue within teaching as being a somewhat malleable tool that could be used to link theory to policy. However, Alexander (2013) felt that dialogue that was drawn from social constructivist theory actually encouraged learners to investigate issues and stimulated their curiosity leading to a wider and deeper understanding of the topic.

Active teaching approaches are constantly being scrutinised, Binson (2009) investigated a CBL approach to teaching using learner centred reflection as a key part of the process, suggesting that circular models of reflection (e.g. Kolb, 1984; Schön, 1991) were too focussed on internalising the learning. CBL, on the other hand, allows the learner to adopt a linear reflective process where the process leads to a transformed understanding and thus a new perspective. This transformation requires the whole programme to be delivered in a consistent manner, not in a few iterative episodes – a view shared by Van Berkel (2010). Some element of reciprocity is required for teacher and learner alike to benefit from such an approach, thus keeping it fresh, topical and interactive (Spronken-Smith, 2006; Alexander, 2013). This consistency aspect could be considered as an issue for the research presented here in that only one element of the teaching programme will be changed. However, the teaching approach will still deliver the same learning outcomes using the same teaching and learning materials thus only the learner engagement aspects will actually be affected keeping the programme itself intact and consistent.

A teaching approach that produces a curious learner is difficult to define as it contains both didactic and self-determined elements in what has come to be known as blended learning and may need to rely on more difficult to identify/quantify personal factors such as transformative teaching and learning (Mezirow, 2003). The proposed research looked to develop a pedagogical model incorporating learning ‘pull’ factors and teaching ‘push’ factors from which new theory could develop regarding motivational aspects of learning. Abeysekera and Dawson (2015) explore the use of self-determination theory. This was originally proposed by Deci and Ryan (1985), as a way to evaluate the likely success of pedagogies that promote active learning such as the flipped classroom, by evaluating levels of student competence, autonomy and ability to relate the topic to their own needs.

Previous CBL research indicated there was value to the CBL approach (Jackson and Ward, 2012). However, using an even more immersive approach, such as the flipped classroom approach from Tucker (2012), was more likely to result in different outcomes and new knowledge that could inform pedagogical development in engineering disciplines. The flipped or inverted teaching approach, originally proposed by Lage and Platt (2000) through use of the internet in teaching, required the learner to pre-read materials, the learning outcomes of which are then consolidated in subsequent exploratory, discursive active teaching sessions. Everett et al (2014) explored improved problem solving and knowledge transfer in a small cohort through a hybrid flipped first year engineering course on the basis that engineers learn better through being actively involved in their learning. Using the flipped approach allowed this research to explore both CBL and dialogic methods acting in conjunction for any impact on student motivation, learning and thinking style.

2.2.2.4 Thinking styles theory

Research into the way learners think about their learning continues to develop. Gregorc (1984) and Edward de Bono (1985) along with Benziger and Sohn (1993) consider many aspects of learner preferences. Pogrow (1988) asserted that the development of thinking skills helps to prepare students for both education and life after education. To add to the potential for confusion in this topic area, thinking styles and cognitive styles are often taken to have the same meaning. Indeed, cognitive theory discusses bias in thinking and argues that it affects an individual’s decision making and that unhelpful thinking such as jumping to conclusions, over-generalising or assigning labels to things affects their actions too (Burns, 1980). More recently Kadir (2007) proposed a key driver for a transformative learning was critical thinking. The way we think and assimilate learning is a complex issue, indeed Benziger (2013) further clarified that an engineering learner’s natural thinking style should be considered along with their inherent unconscious bias when categorising them into one of two (ordered or analytical) preferential thinking styles. Given that learners will have a preferred or dominant thinking style, all learners can (should they choose), adopt different thinking styles as appropriate. However, given the two categories above, a single teaching approach is unlikely to be suitable for all engineering learners. The link to the use of didactic or auto-didactic pedagogical approaches is likely to be dependent on previous teaching experiences that bring out the 'best' thinking in the student cohort for the desired learning outcome and is thus affected by the preferences of the teacher. This harks back to theories surrounding teacher influence and policy drivers (Friere, 1986) with no consideration for learner ethnicity and cultural background, which are arguably key components in the way that a learner thinks, approaches their learning and consolidates their depth of understanding.

2.2.2.5 Learning styles theory

Learning style theory and thinking style theory have developed at the same time with both linked in many of the models produced (e.g. Kolb, 1984; Benziger, 2013). Learning styles can be defined in the HE context as a set of conditions under which a student is most likely to learn to the best of their ability. The provision of suitable learning environments is key where classroom design and available technology help settle a learner into a suitable frame of mind for the planned learning experience (UCISA, 2016). Many learning style models were developed to identify specific preferences of learning style (e.g. Dunn et al, 1984; Kolb, 1984; Kolb, 1999; Honey and Mumford, 2000) rather than to determine the discrete conditions of learning for any one student. A learner's state of mind was felt to be a key contributor to the effectiveness of the teaching and theorists investigated emotional intelligence traits (Gardner, 1993; Goleman, 1995 and Mayor and Salovey, 1997) developing their theories from Jung's (1933) original work on extroversion and introversion in the psychological domain. Jung's (1933) work exposed factors that are recognised as having an impact on working relationships and are regularly explored through the use of the current Myers-Briggs Type Indicator but not identified directly as a possible impact on learning in an educational setting (McCaulley, 2000).

However, there is considerable debate about the actual reality of learning styles, especially in the psychology arena, and their acceptance as fact without any supporting evidence (Willingham et al, 2015). A short but instructive article by Norman (2009) questioned the validity of learning styles because they can be shown, in numerous studies, to have little or no effect on the learner, despite the style of teaching adopted. Cuevas (2015) gives a detailed review of each of the main learning styles models and concludes that none of them have any relevance to the learner or the delivery of teaching. Later reviews and research into the impact of learning styles specifically using a flipped classroom compared to a traditional classroom environment (Nwokeji and Holmes, 2017), found some differences attributable to the teaching approach where students were analysed by being grouped in preferred learning style e.g. visual, auditory etc.

It can be seen that all of the theoretical aspects mentioned above are key to determining how best to approach pedagogical design. Identifying knowledge on preferred thinking and learning styles informs the development of appropriate pedagogical approaches that take account of teaching theory as it has developed across all aspects of learning.

2.2.3 Teaching

Setting out clear aims and objectives for learners to enable them to understand and ultimately achieve the required learning outcomes is vital (Wallace, 2005). Didactic and active teaching approaches both set out to achieve similar aims but in different ways.

2.2.3.1 Teacher centred and traditional lecture-based approaches

A teacher centric didactic approach sees the teacher delivering a lecture where the only interaction between teacher and learner would be to clarify a teaching point. The main teacher centric approaches for delivery of teaching material are:

- Pure lecture
- Demonstration
- Instruction
- Conference
- Examination

Barell (1998) indicated that there was a trend towards more self-direction in learning but the need to stimulate a learner’s curiosity to enable a more self-directed approach was key, especially in first year students.

2.2.3.2 Active teaching approaches that are fully or part learner centred

The main active teaching approaches can be broken down into two sub categories, semi-guided and unguided. Semi-guided can be seen as a teacher/learner hybrid approach where unguided teaching is purely learner centred and entirely dependent on the learner to self-motivate. The main active teaching methods are summarised in Table 2.1 below.

Table 2.1 – Active teaching/learning methods (modified from Jackson, 2016)

	Type of Instructional or Learning Method
Semi-Guided	Q&A Sessions; Seminar; Case Study; Discussion; Tutorial; Role Play; Worksheets; Practical Sessions; Directed Reading; Assignment; Facilitation; Modelling; Coaching; Problem Based Learning; Enquiry Based Learning; Curiosity Based Learning; Studio Based Learning; Scenario Based Learning (case study after lecture); Flipped Classroom (directed reading followed by case study within lecture); Dialogic Teaching; Peer-Assisted Learning; Collaborative Learning; and Co-operative Learning.
Unguided	Pure research; Research project; Group working; Self-directed study; Problem solving; Experimentation.

Kirschner et al. (2006) felt that unguided approaches with their lack of consistency and a reliance on students to take responsibility for their own learning are not as effective as guided methods. Hmelo-Silver et al. (2007), disagreed with Kirschner et al.'s article, stating that unguided methods should not all be treated in the same way. They linked their argument to individual preferred learning styles and, as we have just seen, the learning style tenet is itself still under debate raising further uncertainty about the value of designing teaching approaches to suit learning style. However, adults were found to be self-directed in their learning in a previous study which was a relevant factor for the target population in the research presented here (Tough, 1971). Curiosity Based Learning (CBL) is a constructivist or experiential learning approach that is differentiated from similar approaches by adopting a non-scripted phase, similar to a flipped approach, during the learner exploration of the topic allowing learners to decide how to discuss, investigate and understand the topic rather than relying on the teacher to script the learning for them.

Constructivist teaching methods tend to be teacher centric but can be grouped into a 'guided' or 'semi-guided' category where learners tend to be passive participants. Healey (2005) discusses the rise of inquiry-based teaching approaches and their effectiveness whilst Khun (2005) argues that active teaching can help the learner towards independence in their learning assuming that sufficient guidance is provided along the way. Monitoring a learner's engagement with and progress towards achievement of stated learning outcomes is problematic but will probably become easier through the wider use of technology infrastructure provision (van Berkel, 2010). The CBL approach includes short teacher-led sessions to inform the overall direction of research. Table 2.2 sets out the different features of a CBL style active learning approach compared to other similar semi-guided approaches (Binson, 2009).

Table 2.2 – Features of active learning approaches (adapted from Binson, 2009)

Common Features	Unique Features of CBL
• Focus is on the learner; • The teacher acts as a facilitator; • Learners are encouraged to investigate and explore a topic or a problem thoroughly; and • Groups need to be interactive.	• Learner activities are designed to stimulate the learner to be more curious; • Learners become more aware of the importance of asking questions (curiosity); • Learners become more able to overcome their own limitations where investigating a topic; and • Learners gain experience of defending their own research through a better awareness of research methods that can be used in future research.

Horn (2013) presented evidence of the benefits of a flipped classroom environment, that indicate similarities between the flipped approach and CBL where learners are encouraged to learn through individual enquiry and group dialogue. The flipped environment actually requires learners to take more responsibility for their own learning through preparatory pre-session activities. Key to the flipped aspect is the opportunity for learners to approach the set lecture material at their own pace and use the follow-up session to reinforce their understanding rather than follow a pre-scripted set of experiments or tests to solve a specific ‘problem’ (in a problem-based learning context).

With the need for policy drivers to be addressed (Ball, 2013) and ever more societal pressure to have ‘ready to work’ graduates (RAE,2007, 2016; IET, 2016), a teaching approach that helps to instil confidence and self-belief in the learner is identified. The most effective approach for engineering teachers to adopt is still unclear and could be a mix of didactic and active approaches to suit the topic.

2.2.3.3 Learning/Thinking styles in teaching

We saw earlier that learning and thinking styles are related and that individuals have their own preferred styles but that a variety of learning and thinking styles can be adopted to suit the learning need. Long-term improvements in learner achievement for confident selfstarters have been identified where they have experienced active approaches to teaching in their HE studies (Spronken-Smith et al., 2008). The reasons for these findings are still not clear but psychological factors such as ego states (Berne, 1961) and the theory of Transactional Analysis, may partly explain why learners adopt different approaches to learning throughout a course of study. Table 2.3 presents a simplified overview of these categories for both teachers and learners as they relate to this research.

Table 2.3 – Possible roles in thinking or learning Cohorts (adapted from Berne, 1961).

Ego State	Type of Role for a flipped approach
Parent	Teacher in advisory/facilitative/guidance/mentor role (constructivist approach). Learner in empathetic/supportive role both intra and inter team (critical and reflective thinking aspects).
Adult	Teacher encouraging self-directed activities and/or dialogic interaction (discursive, constructive criticality approach). Learner carrying out autonomous research, determining their individual or team approach to research with minimal guidance (confidence/transformative aspects).
Child	Teacher listening to learner responses, questioning the focus (blended approach). Learner responding without thinking critically or reflexively.

The research presented in this report evaluates the effectiveness/impact of an active teaching approach where the teacher adopts a guiding or facilitative role similar to that of a parent (using Berne's terminology). How the learner copes with the information will depend to some extent on their current state of mind but will also be affected by the teaching approach too. Paul (1984) feels that developing critical thinking skills not only improves learner capabilities during HE but also as they progress into industry, contribute to society and become more willing to consider moving towards a transformed perspective (Mezirow, 2003). Active teaching approaches could be the way to encourage critical thinking, improve skills needed by society and fulfil policy driver intentions. However, designing a curriculum for HE engineering students would need to include more collaborative learning spaces, discussion and meeting spaces rather than rooms or lecture theatres in the 'traditional' sense (UCISA, 2016). There is more provision of such spaces evident in many universities and thus the environment for use of more active teaching such as CBL and dialogic teaching in engineering subjects is emerging. However, due to the varied nature and scope of engineering topics, not all subjects are suited to these more active teaching approaches or the use of a flipped classroom environment.

Developing our ability to be more confident in critical thinking (Yong, 2010) is consistent with Mezirow's theories of transformational learning. Critical thinking is encouraged through dialogue within the classroom (Alexander, 2008) and outside during social interaction (Goulah, 2009) but a learner's level of self-efficacy (SE) will determine the eventual level of learning. One could argue that this indicates a student's willingness or motivation to learn can be affected by the pedagogy (Cole et al., 2004). These factors and more are developed in a model created by the author (see Figures 2.1, 2.2 and 2.3) that has informed the research reported in this thesis and the model has itself developed through the research.

Fig 2.1 The elements of active teaching for CBL (adapted from Jackson, 2014)

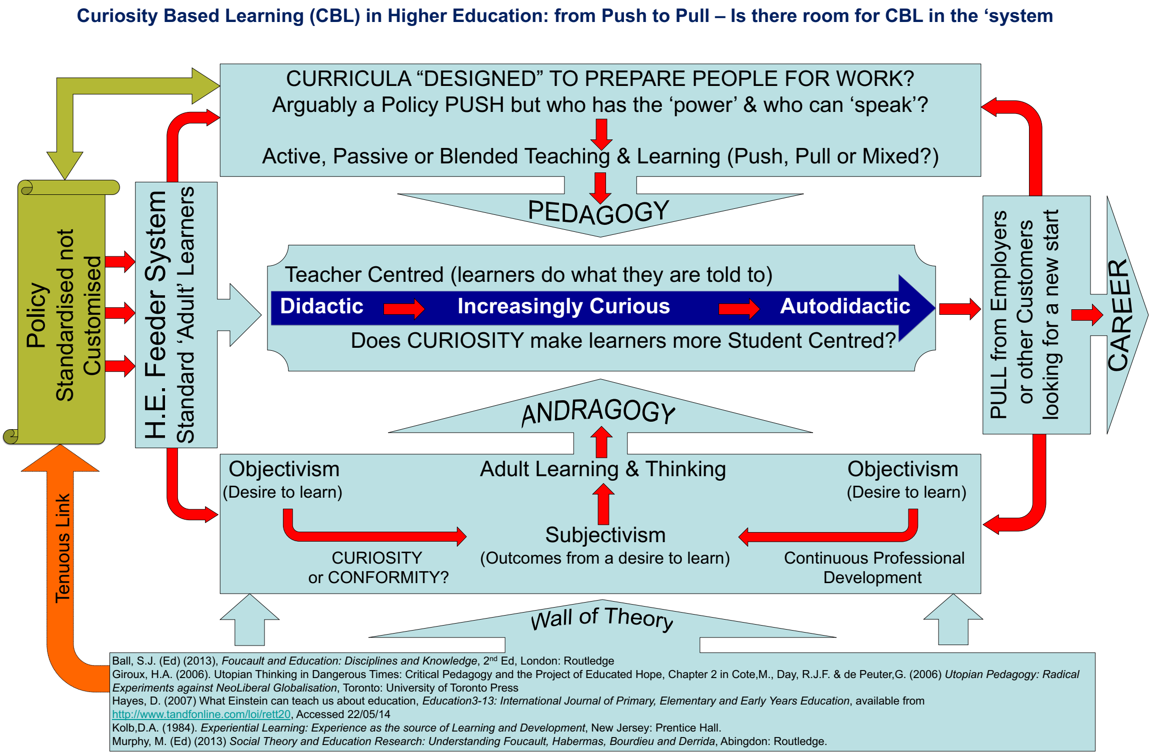
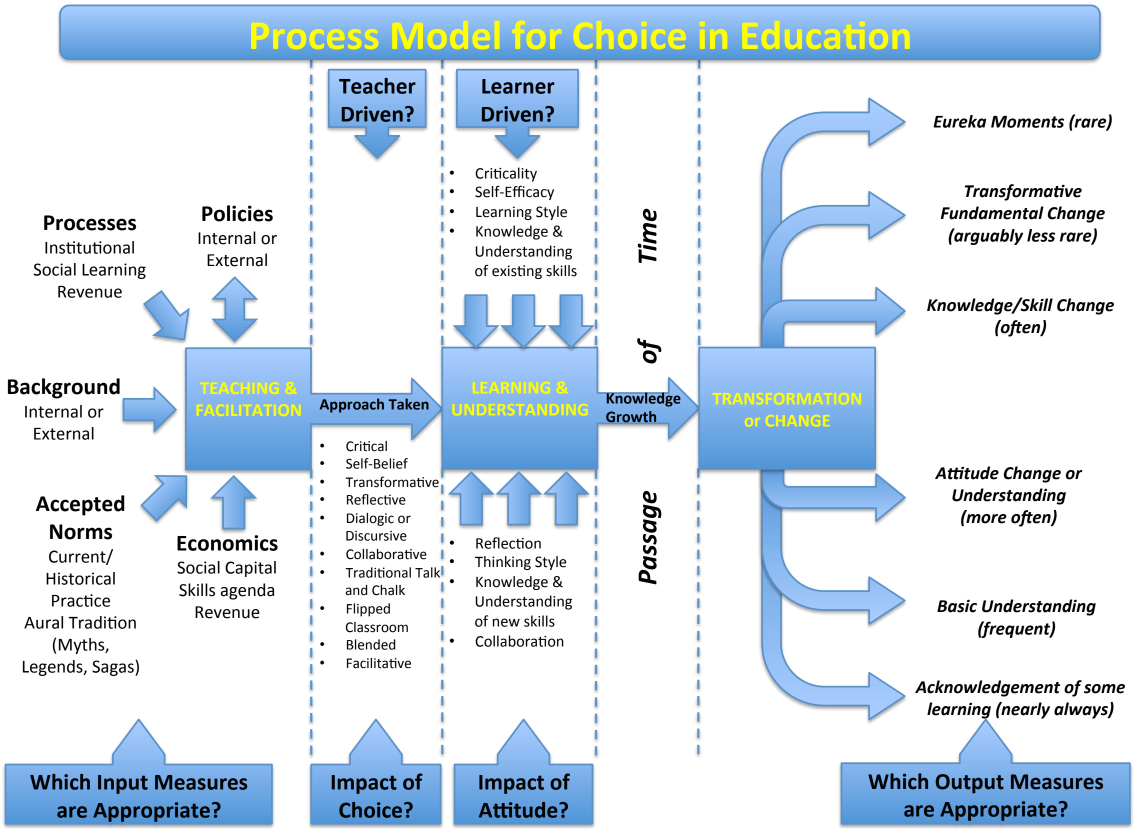


Figure 2.1 is taken from a poster produced during the second module of the author's Doctorate in Education to explore the use of CBL in engineering education. The model incorporates many factors and offers some possible linkages between theory, policy and practice. The original study into CBL explored the development of alternative methods for engaging engineering students in their learning. One can see that the original

understanding of teacher and learner centred approaches was not clear to the author as one cannot make a learner more student centred. However, one can make the *learning* more student centred through the use of active teaching approaches. Further research and literature reviews led to the development of a more structured model of the processes involved in producing a more developed student (at the end of their respective course of HE). Figure 2.2 below depicts the first iteration of this process model.

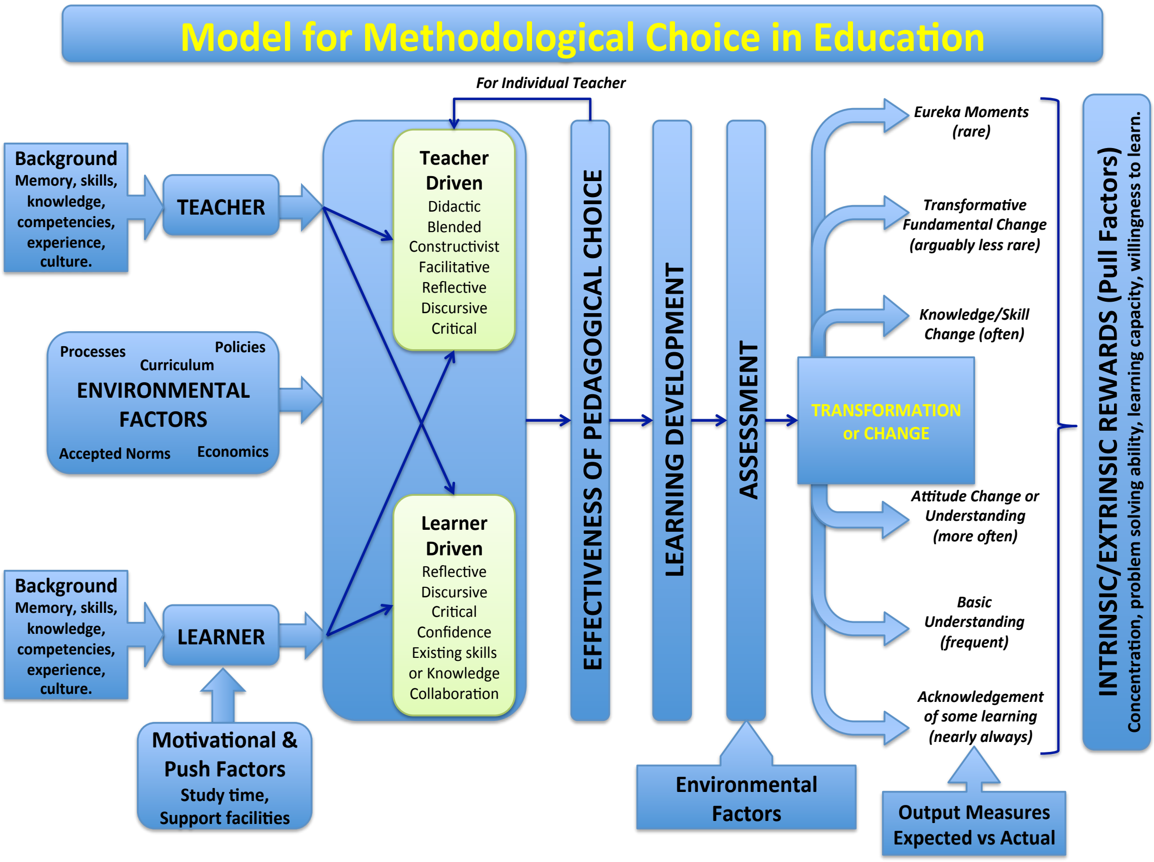
Fig 2.2 Initial process model developed from literature search findings.



In this first model we see many questions raised about input measures, impact of choice and attitude, teacher drivers, learner drivers and output measures. The model squeezes many factors into these sections with only policy being identified as a two-way flow where industry, HEIs and governments have influence. What it did not take into consideration was the mutual influence between teachers and learners or the feedback loop needed for continuous improvement. There were also environmental factors that could be grouped and their respective influences inserted at appropriate stages. The model was refined for more effective representation of the literature when it was realised that there was no obvious research evidence of direct positive feedback mechanisms existing within the pedagogy regarding the effectiveness of pedagogical choice for large cohorts of students in HE engineering courses.

The re-configured model helped position the overall context for this research in an HE setting (Figure 2.3) and indicated that there were three main input sources via 1) the teacher, 2) the learner and 3) the environment of HE. The term ‘confidence’ actually referred to self-efficacy (SE) but was modified to simply ‘confidence’ in the learner driven area of the model, for ease of presentation. In Figure 2.3 we see these refinements and also the introduction of push and pull factors that affect the entire process but that would benefit from further investigation to understand their impact on HE engineering students.

Fig 2.3 Refined process model



Self-efficacy theory can be traced back to Bandura (1977 and 1986) and deals with how individuals approach a task which in turn relies on their own evaluation of their abilities and capability to take on the given task. Theoretical aspects impact upon the model at input stages (push factors) where theory has informed policy, environment, teaching practice and the condition (knowledge, attitude, self-esteem, self-efficacy) of learners as they enter UK HE engineering courses. In the current employment climate students are encouraged to attend HE and achieve higher awards to attract better jobs which could equate to the desire or motivation (pull factor) to do something that, for example, might help pay off student loans. Some learners will change a little, some will change a lot but it is not clear why or how this might be addressed by pedagogical approaches to achieve maximum gain for all learners. Indeed, it is not clear what ‘maximum gain’ would be for any one of the learners unless one tries to understand where the learner came from, where they wish to end up and their respective levels of skill, knowledge, self-esteem and self-efficacy, i.e. create a baseline from which to identify which of these pull factors is a) significant and b) able to be influenced through pedagogical design. Exposure to and practice at doing tasks gives experience and is likely to give more confidence, especially where failure occurs that is subsequently overcome establishing a link to transformative learning aspects discussed above. Social and cultural aspects, along with mood and emotional state are also sources of confidence. Pajares (1996) discussed elements of Bandura’s thinking and related them to the study of motivation in educational settings supporting the clarification of linkages between self-confidence and motivation in learning thus leading the research presented here to consider the term ‘learning’ more carefully.

2.2.4 Learning

Learning, as a word, can have meaning in many different contexts:

- For policy makers, there is a focus on learning skills for use in future careers putting pressure on HE institutions to include these skills within the learning outcomes;
- For teachers, learning falls into two broad camps: a) surface learning for short term use and b) deep learning for longer-term uses. Spronken-Smith et al. (2008) assert that active learning is more likely to promote longer term deep learning through reflection, critical thinking and critical analysis. Mezirow (2003) and Alexander (2013) agree as they promote collaborative learning and dialogic approaches in the classroom to achieve deeper learning; and
- For learners, the ability to assimilate required knowledge and skills are key. We are informed by previous research (Vygotsky, 1978; Dunn, 2000; Coffield et al., 2004) that learners are influenced by their respective backgrounds and as such may not conform to any one specific model. Use of a specific style of teaching might affect individuals differently due to their own preferred learning styles. Learning styles have been and are still being debated but they can be categorised as follows:
    a. Visual
    b. Auditory
    c. Kinaesthetic Tactile

  The research reported here has taken these aspects into account to identify a baseline for each respondent against which changes over time can be evaluated.

The concepts of scaffolded and collaborative learning, introduced by Vygotsky (1978), allowed teachers to adopt a different approach from the traditional didactic methods employed in the majority of HEIs at the time. The original use of CBL by the author allowed a form of scaffolding to be present and support for this is evident in more recent publications (Kerr, 2015) where having reviewed the research on flipped classrooms, a measure of scaffolding such as mini-lectures was suggested as a practical implication for flipped classroom approaches. The second Cohort of the research reported here used group/collaborative learning in the classroom allowing students and teachers to learn from each other (The Boyer Commission, 1998; Brew, 2003; Spronken-Smith, 2006; Spronken-Smith et al., 2008). The wealth of knowledge regarding learning styles and models used to assess an individual's learning style is shown in Kolb's (1984) learning styles inventory, Honey and Mumford's (1992) learning styles questionnaire and Dunn and Dunn's learning styles model using the VAK approach for their physiological dimension (Dunn, 1990). The research reported here considered the above issues and addressed the validity of previous CBL studies whilst evaluating the usefulness of a flipped classroom approach in engineering teaching.

2.2.5 Outputs and linkages

The discovery of limited research into active teaching and learning within a HE engineering context (Toto and Nguyen, 2009; Zappe et al., 2009) boosted this researcher's confidence that the research carried out could add to the overall knowledge base as well as build upon and clarify previous research outputs (Khun, 2005; Binson, 2009, Jackson and Ward, 2012).

Key drivers for teaching and learning are found in policy (Ball, 2013; Cartwright and Hardie, 2012; RAE, 2016; QAA, 2016) and also in critical thinking (Kadir, 2007). There is some indication that revising the style of teaching to which learners are exposed may lead to transformative learning (Benziger, 2013; Mezirow, 2003). However, there are other environmental factors (UCISA, 2016) that may affect such a transformation, these include culture (van Berkel, 2010) and motivation (Dewey and Bentley, 1949; Deci and Ryan, 1985; Rumble, 1986; Walkin, 2000; Laurillard, 2002). Consideration of the above drivers helped set the context for the research reported here.

Mezirow, (2003) felt that in order to achieve a transformed state of understanding, learners need to be allowed the space and given the guidance to improve their knowledge and understanding. The teaching approach used to facilitate such a change or transformation encourages curiosity, dialogue and builds confidence (Alexander, 2013). Active approaches are seen to be more effective and by using an inverted or flipped approach HE engineering students may benefit (Tucker, 2012). The initial model produced by the author (Figure 2.1) outlines factors that feed into such a process of transformation through pedagogical choice This model was further developed into a process model (Figure 2.2) and then refined again as more information emerged through the research allowing the model to incorporate what the author has termed push and pull factors (Figure 2.3). This transformed perspective shown at the output stages of Figures 2.2 and 2.3 take account of Mezirow's thinking (2003) and Merriam's (2004, p.60) assertion that in order to achieve transformational learning one must already "…be able to critically reflect and engage in rational discourse; both of these activities are characteristics of higher levels of cognitive functioning." These aspects were underpinning factors in Kadir's (2007) research on critical thinking and transformative learning and allowed the definition of the data required for assessing learning outcomes dependent upon the teaching approach employed.

Didactic teaching (talk and chalk in this context) is considered to be closer to the way humans acquire knowledge outside of a classroom environment (Fry et al., 2003). It does not follow that this is always the most suitable teaching approach (Wood et al., 1976; Kolb, 1984; Schon, 1991; Mezirow, 2003; Alexander, 2008).

The research reported here tested an active approach in a HE engineering context by comparison to a didactic approach and evaluated the outcomes. The research aim and the research questions to be answered were:

- Research aim: *To measure the effectiveness/impact of an active teaching approach compared to a didactic teaching approach in electronic engineering students*

- Main research questions:
    - *The flipped classroom – does this dialogic and active teaching approach lead to a change in a learner's preferred learning or thinking style compared to a didactic, passive teaching approach?*
    - *Does a flipped classroom active approach enable students to be more confident in taking responsibility for their own learning and achievement compared to a didactic, passive teaching approach?*

The above research questions were split down further to enable a research instrument to be designed (see Chapter 3 for more on methodology and final research hypotheses) and the following sub questions were defined:

RQ1 – Can an active teaching approach impact upon a learner's desire to learn?

RQ2 – Can a learner's preferred learning style be affected by being exposed to an active teaching approach?

RQ3 – Can a learner's preferred thinking style be affected by being exposed to an active teaching approach?

RQ4 – Does the learner experience a rise in their level of confidence in taking responsibility for their own learning (self-efficacy) when exposed to an active teaching approach?

2.3 Further Review and Research Framework Development

This section explores further literature and thinking surrounding the more traditional versus active teaching methods employed in HE today. A number of aspects were uncovered during research into methodology and whilst completing the research proposal process that suggested that the original framework for pursuing the research programme needed to be re-addressed and refreshed. These aspects included definitions for some of the terminology and concepts used (now included in Chapter 1), hypotheses (this Chapter) and further clarity on the research design (see Chapter 3).

Active teaching and learning approaches tend to be designed to promote a desire in learners to take more responsibility for their learning (Khun, 2005) and are sometimes called meta-learning, meaning the student becomes more aware of their own learning needs and takes more control of it (Biggs, 1985). The identification of learning styles may help in the design of future pedagogical approaches by identifying how best to help students learn how to learn rather than one particular style preference. If we consider didactic teaching to be objectivist (formal), where the understanding comes largely from external sources, is based on fact and can be observed, then active teaching is subjectivist in nature (less formal) as it emphasises the need for internal context, reflection and interpretation (Persson, 2005). As one progresses from formal to less formal or even informal the teaching approach needs to be more supportive but an active teaching approach alone might lead to improved student outcomes (Jensen et al., 2015). We saw from Wood et al. (1976) and Vygotsky (1978) that such an approach could be termed ‘scaffolded’ and requires more interaction by teachers as learners become more curious and collaborative in their learning. We have also seen previously that adults tend to be more self-directed whilst learning, regardless of the effectiveness of the teaching approach (Tough, 1971). Arshad et al. (2015) showed a positive relationship between a student’s self-confidence (self-confidence in this context addresses both current self-esteem and future self-efficacy aspects) and their university performance. This supported earlier work by Locke and Latham (2002) suggesting that a teaching approach that boosted a student’s self-confidence (possibly through scaffolding) could lead to higher academic achievement.

Bleidorn et al. (2016) recently found that males tend to have a higher level of self-esteem than females in the late adolescent to middle adulthood age brackets which is particularly relevant for this research as it establishes the need to measure self-esteem pre and post each teaching intervention. Additionally, being able to assign the results by gender and by age bracket helps point towards possible improvements in learning outcomes and potentially towards improved career prospects in the future (Salmelo-Aro and Nurmi, 2007). These improvements in the research instrument relate to the teaching approach rather than general population trends and as such Chart 2.1 below represents the main drivers on teachers in HE engineering education that have informed this research where Chart 2.2 shows a breakdown of factors affecting learners. Charts 2.1 and 2.2 are produced to help the researcher identify key factors that might impact from a teaching and learning perspective. They include some aspects that were not discretely identified in the earlier pedagogical development models or were shown as environmental factors.

Chart 2.1 – Factors driving the teaching approach.

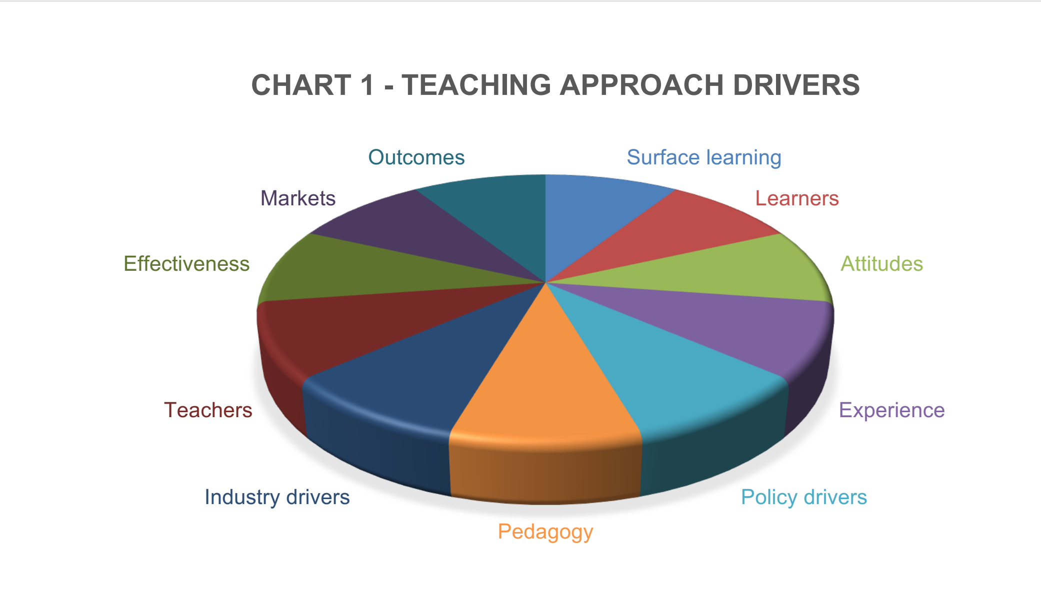
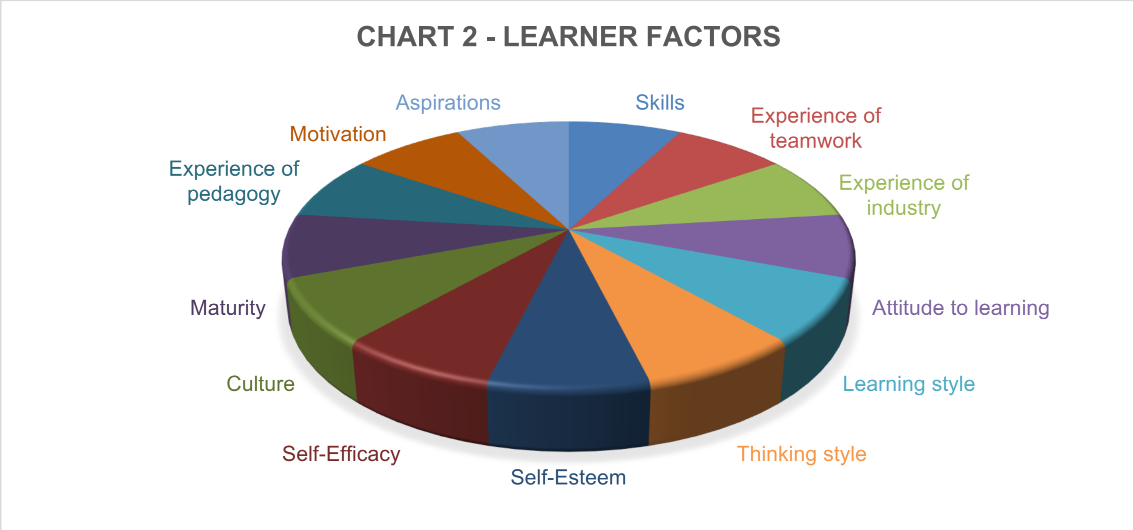


Chart 2.2 – Factors driving the learner



Early research by Felder and Silverman (1988) established links between learning styles and teaching styles in engineering education, suggesting a best fit between the learning and teaching style adopted (see Table 2.4 below). The table presents a view from the late 1980's and can clearly be seen to contain influences from the work of Gregorc (1984), and Kolb (1984) as with many of the models of thinking and/or learning style. However, Felder and Silverman's main findings indicated a large mismatch between engineering students' learning preferences (mainly visual, inductive and active) and engineering education teaching styles (mainly auditory, deductive, passive and sequential). Their work goes on to suggest a mix of teaching techniques that could address all learning styles for all types of learning preference and crucially, for the current research, not a largely passive style.

Table 2.4 - Dimensions of Learning and Teaching Styles (Felder and Silverman, 1988)

Preferred Learning Style	***Corresponding Teaching Style***
sensory or intuitive = *perception of facts*	concrete or abstract = *content of lesson*
visual or auditory = *input type*	visual or verbal = *presentation of information*
inductive or deductive = *organization of information preferred*	inductive or deductive = *organization of teaching*
active or reflective = *processing information*	active or passive = *student participation mode*
sequential or global = *understanding of information (piecemeal or holistic)*	sequential or global = *perspective given to the learner (piecemeal or holistic)*

Clark (2009) refers to the above seminal paper but goes on to discuss the focus of many ‘research’ works in the area of general education that assesses links between learning and teaching style as being merely attempts to improve teaching practice rather than applied research. It is prudent therefore to ensure any research of this nature considers the full rationale and context before commencement such that it provides evidence-based research outputs that are applicable in a HE teaching and learning environment. An evidence-based approach to flipped learning was discussed in a review of research on flipped classrooms in engineering education (Karabulut-Ilgu et al, 2018) where they felt the majority of flipped classroom approaches that they studied, compared the respective learning outcomes in flipped versus traditional engineering teaching. However, there was no opportunity for meta-analysis of the various researches because most did not publish mean scores and so this view was informed partly through a one-way ANOVA (Analysis of Variance) between those researches that did publish means. O’Flaherty and Phillips (2015) and Reidsema (2017) indicated support for use of summative student outcomes (achievement) to determine the effectiveness of the flipped classroom approach as well as measures that used pre to post test results. Indeed, Clark and Andrews (2014) propose such an evidence-based approach to engineering education when discussing Boyer’s (1990) scholarship thinking, applying fundamentals of this thinking to their relationships, variety and synergy (RVS) case study that purports to provide an environment for successful scholarship. There is support for the RVS approach and there are similarities with early CBL designs (Jackson and Ward, 2012), and the current proposed research design to consider key aspects of knowledge, skills, self-esteem and self-efficacy, measuring these through tested or piloted instruments (Ch 3). There is further support for a fundamental review of engineering education (e.g. RAE, 2007; Crawley, 2001, 2014; Graham, 2012; Fidler and Harrison, 2013 and Goodhew, 2014) including frameworks such as the conceive, design, implement and operate (CDIO) model that includes flipped (active) learning as a useable component in one of its standards (CDIO Standard 8 available from http://www.cdio.org).

It is important to recognise the variety of learning style models that exist (see Section 2.2.2.5) but the main model considered for this research was VAK (or VAKT) as it concentrates on whether a learner has a preference for visual, auditory or kinaesthetic learning (Tactile is sometimes added as an extra dimension within kinaesthetic). This type of model is often used to help determine the development of meta-learning in students, which is one of the areas of interest for this study and why the VAK style preference model was chosen. To be clear, models only show a preference for a learning style, they do not predict the actual style adopted by the student at any one time. Given that students are all different and will therefore have different preferred styles and will adapt their own learning to suit the educational material being delivered, the pedagogical design should include a mix of approaches that are best fitted to the required learning outcomes rather than any learning style preference (Coffield et al., 2004).

The study presented here recognises the debate about designing a range of learning style preferences into the pedagogical approach (e.g. Coffield et al, 2004) plus the existence of psychological studies that seem to show the existence of specific learning styles (Thompson-Schill et al, 2009). However, this research also recognises the categorisation of the styles and adds other dimensions discussed earlier, such as self-esteem and self-efficacy, along with prior knowledge and the importance of such for engineering students. Ojonugwa et al. (2015) looked at engineering students from an employability perspective and determined that whilst self-esteem was important in completing tasks, self-efficacy was more relevant when it came to a student's ability to judge their own capabilities to actually perform a task in both specific and general situations. Smith et al. (2010) indicated that people with higher self-efficacy are more likely to recover from unexpected outcomes and that this recovery would be more rapid than those with low self-efficacy. Also, the lower the level of self-efficacy, the more likely the person would be to focus on negative issues arising from any work undertaken. This may indicate that students with high self-efficacy will be more likely to adopt a meta-learning approach. Research carried out by Concannon and Barrow (2010), Schunk (2012), Hsieh et al. (2012) and Shkullaku (2013) all indicate benefits for students through improved self-efficacy. These are evident in terms of enhanced motivation to learn, improved academic performance, and higher aspirations, but the benefits also depend on students having the requisite skills and a positive approach to learning.

There is little evidence to indicate any significant differences between males and females with regard to academic self-efficacy but this was not studied directly in engineering students (Huang, 2013). Indeed, the overall gender balance in engineering undergraduate students is significantly biased towards males so this effect may be difficult to assess.

Furthermore, teachers with high confidence or self-efficacy in their own teaching capabilities can help to foster increased self-efficacy, and improved cognitive development and higher motivation to learn in their students using positive feedback and reward systems. Teachers with lower confidence in their teaching abilities tend towards punishment-based rewards systems for students (Bandura, 1994). In turn, this could negatively impact on students' self-efficacy and a desire to learn through the teacher and their adopted teaching approach. Given the above support for improved self-efficacy, the need to determine the impact on a person's self-efficacy through a specific teaching approach is identified. This in turn informs the pedagogical design that could lead to a more positive outcome for the majority of students in an engineering discipline.

However, the teaching approach that leads to the development of a truly curious and self-efficacious learner is difficult to define and arguably impossible to wrap into one pedagogical model or theory e.g. CDIO. This raises an interesting question regarding the usefulness of pedagogical models in that they are not theoretical but instead represent the current or proposed approach to teaching. Moreover, they must be based on some fundamental principles that could be called a theory from which the model is merely a representation or construct and helps the researcher to break down the research into smaller, manageable chunks. Deeper thinking behind why individuals adapt to learning differently, depending upon the teaching and learning context, shows that such complexity cannot be easily explained. Researchers create models to cater for such complexity e.g. Benziger & Sohn's (1993) work on thinking styles. Fundamental applicability to real life and everyday experience may be the key to some pedagogical models being widely quoted (e.g. Kolb, 1984) whilst others are never heard of. If it is possible to construct a model within which to fit one's own 'programmed' views then the approach modelled will probably be flawed or biased in some way. Critics worry about unconscious or implicit bias in modelling, not just in decision making or in research choices, but fear that it may be a significant contributory factor in many research outputs, especially in an engineering context (McCormick, 2016). However, French (2017) has recently identified that the impact of unconscious bias was less significant than it has been previously thought and as such, bias in the research study carried out here is not considered to be a major factor in modelling or research design.

As this research study developed, it became clear that the original focus of pure CBL would not identify how pedagogical choice could affect learning, thinking, self-esteem or self-efficacy in students. The literature indicated that a more dialogic approach through the use of a flipped classroom blended learning pedagogy would be more effective. Table 2.5 below gives a comparison between the most relevant active teaching approaches identified through the literature and the researcher's previous experience.

Curiosity-Based, Problem-Based, flipped classroom and dialogic approaches were considered to be the most appropriate and were compared to identify the best fit with the research to be carried out. The specific large student cohort was expected to exhibit a change in the collective levels of self-esteem, self-efficacy and meta-learning compared to the previous cohort through the modified teaching approach. As can be seen in Table 2.5, no one of these approaches covers all of the relevant factors so the best fit was chosen. The research has used an active teaching approach thus problem-based learning is ruled out and it is unclear whether curiosity-based learning covers any of the psychological factors. A combination of flipped classroom and dialogic teaching was therefore adopted for the second large cohort as this covered most of the factors identified. The research instruments were designed with this in mind and to identify unclear factors such as self-efficacy changes as well as the students' background, age, gender, ethnicity, previous educational experiences and skills development because these are also factors upon which a student bases their attitude to learning, thinking and achievement.

Table 2.5 – Comparison of relevant active learning approaches.

		Experiential or Active Teaching/Learning Approach			
Factor	Description	Curiosity	Problem	Flipped	Dialogic
Learner	Learner focussed	Y	Y	Y	Y
	Group work expected	Y	?	Y	Y
	Inter-group discussion	Y	?	Y	Y
	Intra-group discussion	N	N	Y	Y
	Awareness of own limitations	Y	Y	?	N
	Use of a model research method	Y	Y	Y	Y
	Develops defensive capability	Y	Y	Y	Y
Teacher	Fully guided approach	N	Y	N	N
	Facilitative approach	Y	N	Y	Y
	Unguided approach	N	N	N	N
Psychological	Self-awareness improved	?	?	Y	Y
	Curiosity level improved	?	?	Y	?
	Self-efficacy improved	?	?	?	?
Exploration	Topics explored/investigated	Y	Y	Y	Y

As discussed above, there is indication from previous research of a positive impact due to the use of flipped classroom approaches, certainly in small student cohorts. This researcher did not, at the time of constructing Table 2.5, find similar evidence for large student cohorts, in an engineering context, within the literature but see Section 3.3 later as the methodology evolved and developed. There are clearly many drivers impacting the effect of chosen pedagogical approaches that have informed the research data collection instruments and the chosen methodological approach. Having trimmed the potential pedagogical approaches from Table 2.1 (see Section 2.2.3.2), Table 2.5 above was subsequently refined to exclude approaches with too many unknowns (i.e. Curiosity, Problem-Based and Dialogic Learning) and focus purely on the relevant aspects for the intended research into large cohort traditional versus flipped classroom teaching as shown in Table 2.6.

Table 2.6 – Comparison of pedagogical approach focus.

		Teaching Approach	
Factor	Description	Traditional Teaching	Flipped Classroom
Learner	Learner focussed	N	Y
	Group work expected	N	Y
	Inter-group discussion	N	Y
	Intra-group discussion	N	Y
	Awareness of own limitations	?	?
	Develops defensive capability	N	Y
Teacher	Fully guided approach	Y	N
	Facilitative approach	N	Y
Psychological	Self-awareness improved	?	Y
	Curiosity level improved	?	Y
	Self-efficacy improved	?	?
Exploration	Topics explored/investigated	N	Y

Table 2.6 starkly highlights how different these two pedagogical approaches are from a student focus and supports the view of Felder and Silverman (1988) that engineering students might well benefit from a different pedagogical approach to that which was prevalent at the time of their own undergraduate study. In the opinion of the author, for engineering students the dominant teaching approach for theoretical aspects remains passive, lecture based, rather than active dialogue and exploration. Passive, lecture-based, approaches are also more common for large cohorts i.e. > 30 students thus the intention to carry out research into large student cohorts is also supported.

The main research aim remained as it was (see Section 2.2.5) but the sub-research questions were modified, see Section 3.2, into individual hypotheses which were investigated through the use of the mixed research methodology described next in Chapter 3.

3. Research Methodology

3.1 Introduction

This chapter explains and justifies the research methodology chosen to investigate the issues identified during literature review periods. Rather than describe in detail all the possible options available, it will concentrate on the method chosen by relating it to other similar studies looking into the procedure that was followed, how that procedure evolved through the research and any ethical issues that needed to be considered. The research questions are reviewed at the end of Section 3.2 and the final focus of the research is refined into individual hypotheses that can be tested through the quantitative and qualitative data gathered.

As seen in Chapter 2, there was a gap identified in knowledge relating to effective teaching methods for large cohorts of engineering students. To address this gap a research method was designed, using Saunders et al.'s (2009) research onion model as a basis (see Appendix 1), that could measure the impact of two different pedagogical approaches. The two pedagogical approaches were a) Traditional Lecture and b) Flipped Classroom and these were applied in turn to successive cohorts of first year undergraduate and 'one year' taught masters postgraduate students. There were five elements of the impact to be measured, identified during the discussion in Sections 2.2 and 2.3: a) the learner's desire to learn (meta-learning), b) the learner's preferred learning style, c) the learner's preferred thinking style, d) the learner's self-esteem and e) the learner's self-efficacy. The use of purely quantitative methods to collect data through questionnaires was initially thought to be the best way of collecting the base data. However, pure statistical analyses of responses over time, whilst relevant, were likely to be insufficient to fully explain all results. Therefore, a qualitative element was introduced to explore and provide some additional meaning and/or explanation for any unclear results that emerged during statistical analysis.

3.2 Research philosophy

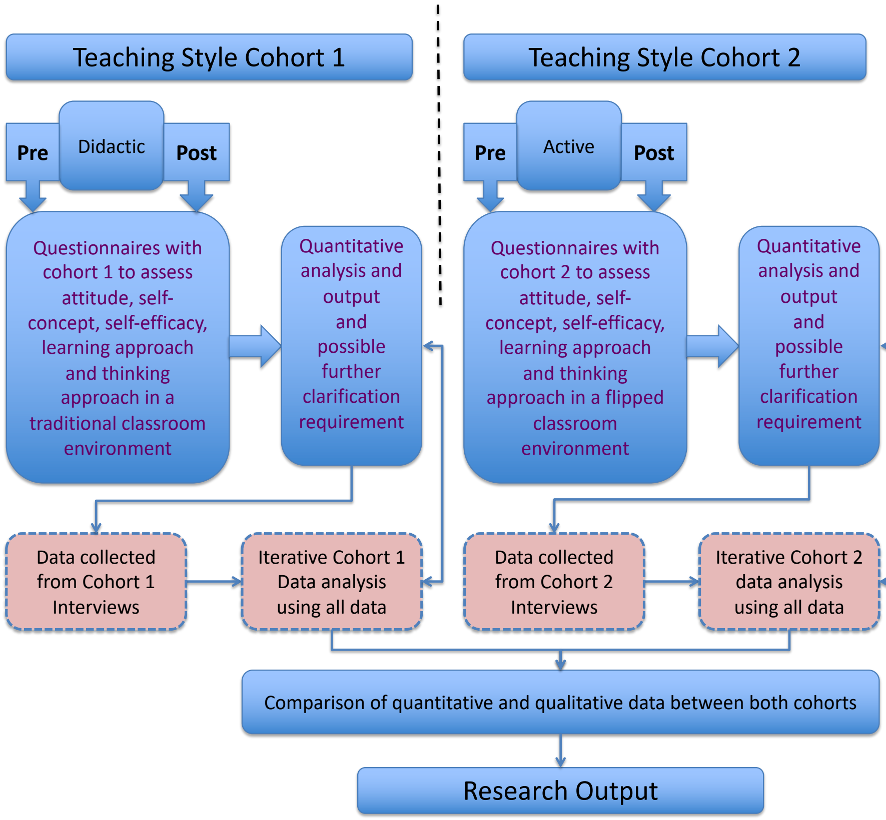
It was helpful to consider which research framework would best inform the research design and to produce a model of what the research encompasses (see Fig 3.1), these frameworks are known as paradigms or philosophical stances (Basit, 2010). Research distinguishes between two main paradigms, positivist and interpretivist (Collis and Hussey, 2009) and considers a paradigm to be a philosophical framework that guides the conduct of scientific research. Bryman and Bell (2015) specify the paradigm to be an inclusive group of rules, beliefs and behaviours that researchers should follow in order to decide upon the study topic, carry out information gathering and interpret the results. The main philosophical stances are set out here with justification for those used in this research.

The philosophical approach adopted in the research presented here, distilled from the work of Collis and Hussey (2009, p.58) and Creswell (2014, pp.6-11), encompasses elements of positivist and pragmatist approaches. Pragmatic research assumes that reality (the ontological perspective) is based on what works in the real world and that researchers can build validity in their knowledge (their epistemological stance) through interaction with or independence from that which is being researched. Therefore, this research had an objective, unbiased axiology ensuring standards of validity and reliability were maintained. The positivist style of data collection sits comfortably within a pragmatic approach as does the simultaneous collection of qualitative data during the research.

Combining the two data types in a mixed methodological yet pragmatic approach has provided a richer yet positively weighted output that might be suitable for consideration more generally. In a deductive study of cause and effect, where a static design is used for research instruments, results can be more accurate and reliable. When trying to determine whether a theory of program change works (i.e. is transformative) using such a mixed methodology, where quantitative and qualitative data is used in combination, is appropriate. This mix of positivist, transformative and pragmatic elements is not unrealistic given that the research was carried out over an extended period of time and incorporated the views of two distinct cohorts of first year students as well as two cohorts of taught postgraduate students. Correlating such data over an extended period was possible through analysis of cohort specific data (Stuckey et al., 2013).

The research methodology adopted was to measure the impact of each of the pedagogical approaches identified in Chapter 2, with subsequent cohorts of students, taking a pragmatic approach (see Fig 3.1 below). This research process model should not be confused with previously discussed process models for pedagogical choice from Chapter 2. Rescher (2000) considered pragmatic approaches in scientific research to be valid as they require practical answers to hypothetical questions allowing a mainly positivist approach to be taken (quantitative) but with the addition of qualitative data in a mixed methodology. Historically there is support for the use of mixed methods research e.g. Hawthorne's ground-breaking studies during the 1930's, where a combination of empirical data, observed outputs and interviews were used to assess the impact on cohorts of workers of applied differences in their respective working environments. The benefit of using a mixed methods approach in this research is the ability to identify patterns and correlations between data items from a quantitative perspective yet add depth and breadth to enhance those outputs through qualitative investigation. In this way, an element of triangulation in the research outputs is provided that may help to explain, at least in part, anomalies or interesting findings within the data (Creswell, 2014).

Fig 3.1 – Data collection and analysis Cohorts

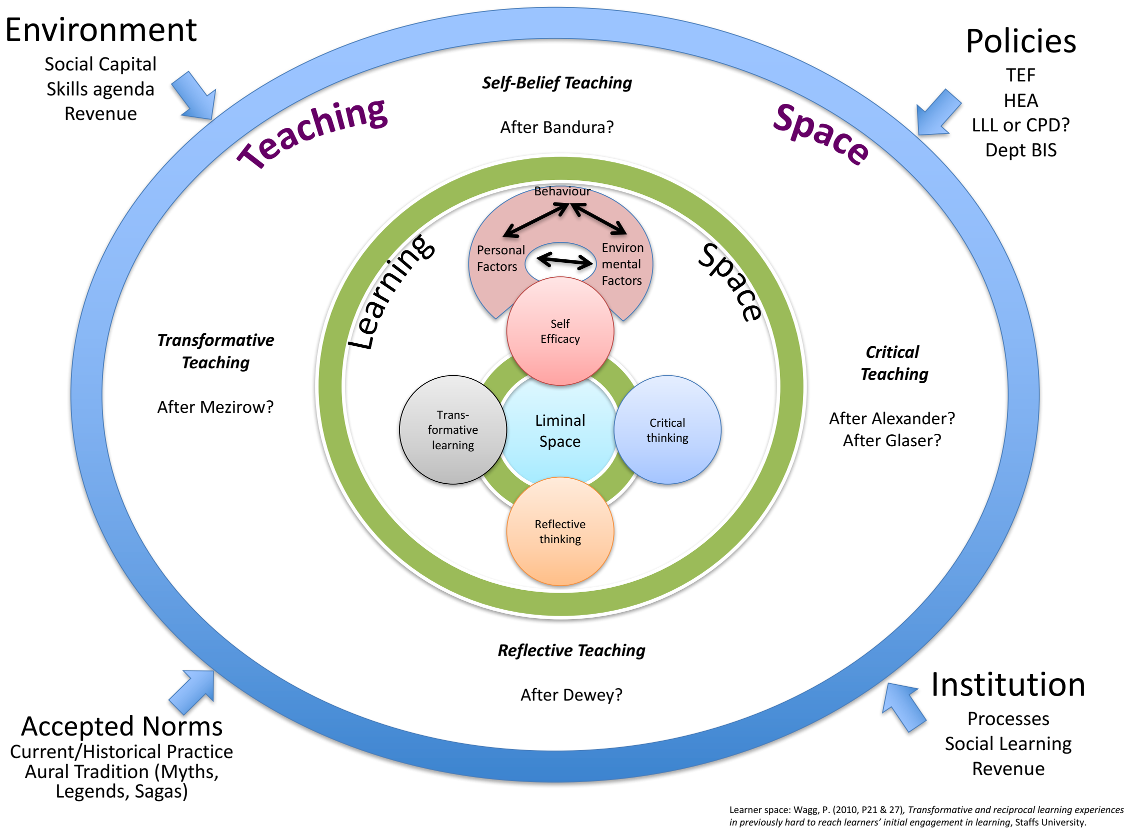


The research method shown in Figure 3.1 is iterative in nature in that the quantitative outputs are used to inform the qualitative questions which in turn are re-used to inform any further analyses or to support the original analytical findings. The research can therefore be considered as a quantitatively dominant, explanatory and sequential mixed methodology that seeks to explain the impact of actions taken by the educator in the course of pedagogical practice (Johnson and Onwuegbuzie, 2004).

3.3 Research Methodology Evolution

This research developed significantly as the literature on aspects of policy, theory, teaching, learning, psychology and ethics was discovered, critiqued and synthesised. As explained in Chapter 1, many of the drivers of recent higher educational policy such as life-long learning, widening participation (Dept BIS, 2012) or the Teaching Excellence Framework (DfE, 2016) led to the adoption of teaching approaches that in turn may have affected the learner in some way. It was not clear whether the impact of centrally-driven policy change upon the learner was positive or negative so this in turn led to further theoretical research. At an early stage, the researcher devised a model of influences that impact upon the choice of pedagogical approach (Fig 3.2 below). This was derived partially from the work of Wagg (2010), where learning space and liminal space (where, in this context, the processing of new knowledge takes place) were exposed, to incorporate external drivers and approaches proposed by theoretical study. This allowed the researcher to set some context that could be further developed, as other factors became clearer, into a process with inputs and outputs discussed earlier (see Figures 2.1 and 2.2).

Fig 3.2 – Initial view of the influences on teaching and learning (adapted from Wagg, 2010)



The literature had suggested that a methodology was needed that was suitable for research into the impact of pedagogical approach on engineering students in a HE setting. It also suggested that traditional teaching methods (lectures) are not the most effective for use in engineering teaching and that active teaching methods would be better (Felder and Silverman, 1988). Looking into these aspects led the researcher to consider comparing a traditional 'talk and chalk' approach with a more active style (see Table 2.5). This built upon the researcher's previous teaching approaches with active teaching to small cohorts and eventually to a flipped classroom approach that would test the extremes of pedagogical choice (see Table 2.6). There was no readily available research evident into flipped classrooms in larger HE engineering cohorts but there was some evidence that it had a positive impact on smaller cohorts. The researcher has posited that since there was no evidence that a flipped classroom would be inappropriate in large cohorts it was a valid topic to research and sufficiently narrow in scope as to be practical and achievable. Indeed, further review of the literature has uncovered supporting evidence from Australia (Reidsema et al, 2017; O'Flaherty and Phillips, 2015) that a flipped classroom approach can be effective in large cohorts of first year students but that it needs careful design as there was evidence of resistance by students to a new approach supporting the proposed research presented here. This support came from the fact that measures of effectiveness in the above studies tend to rely on comparisons of summative outcomes whereas the study presented here looked at resultant attitudes, motivational factors and self-belief in students such as professional skills and knowledge (see Miller, 2017 and Karabulut-Ilgu et al, 2018).

Finally, the research population originally identified for this study needed to be sufficiently unaccustomed to HE pedagogy in the UK as to have the fewest barriers to whatever style of pedagogical approach was delivered to them. Also, the research would be more valid if students were exposed to the teaching approach as soon as possible after they entered the HE system to avoid cross-contamination effects of other modules being taken alongside the one chosen for this study. The researcher subsequently selected a first-year undergraduate cohort in their first term of teaching (September to December). As mentioned earlier, ethical considerations, as required in any research, meant that students were free to take part in the research or not and thinking ahead, rather than relying totally on gaining a good percentage response from the first-year cohort (circa 120 students), the researcher also decided to carry out the same study with another cohort. The only suitable cohort, comprised of a majority of international students with no previous experience of UK HE environments, was the 'one year' taught masters postgraduate student cohort due to commence their course at the same time as the first-year undergraduates. This meant modifying the quantitative research instrument slightly to include ethnicity data and was subsequently included as an extra element in the second Cohort of data collection for undergraduates as well.

The main research questions were still:

1) *The flipped classroom – does this dialogic and active teaching approach lead to a change in a learner's preferred learning or thinking style compared to a didactic, passive teaching approach?*
2) *Does a flipped classroom active approach enable students to be more confident in taking responsibility for their own learning and achievement compared to a didactic, passive teaching approach?*

The above research questions were split down further to enable a research instrument to be designed and the following sub questions were defined:

RQ1 – Can an active teaching approach impact upon a learner's desire to learn?

RQ2 – Can a learner's preferred learning style be affected by being exposed to an active teaching approach?

RQ3 – Can a learner's preferred thinking style be affected by being exposed to an active teaching approach?

RQ4 – Does the learner experience a rise in their level of confidence in taking responsibility for their own learning (self-efficacy) when exposed to an active teaching approach?

The original hypothesis however, allowed no distinction between self-esteem and self-efficacy. Indeed, it was discovered that each of the sub questions was itself a hypothetical construct and so these were further developed.

Original hypothesis:

H1 – Using an active teaching approach impacts a learner's desire to learn by affecting their learning and thinking style and their willingness to take the initiative.

H0 - Using an active teaching approach has little or no impact on a learner's desire to learn or on their willingness to take the initiative.

The four sub-questions (RQ1 to RQ4) became 5 discrete hypotheses to be addressed in the context of traditional classroom passive teaching versus a flipped classroom active teaching approach and the original alternative hypothesis above was discarded:

H1 – An active teaching approach impacts positively upon a learner's desire to learn when compared to a passive teaching approach.
H2 – A learner's preferred learning style can be affected by being exposed to an active teaching approach.
H3 – A learner's preferred thinking style can be affected by being exposed to an active teaching approach.
H4 – A learner's belief in their current abilities (self-esteem) is affected by being exposed to an active teaching approach.
H5 – The learner experiences a rise in their level of self-efficacy and takes more responsibility for their own learning when exposed to an active teaching approach.

3.4 Research Procedure

The research was focussed on circa 17% of the taught course material for each cohort of students (during the 'Engineering Design' module) and so it was a concern that other teacher's pedagogical approaches, on the other modules of the course, would impact the research. Having identified this as a potential issue, teachers of other modules for the cohorts were approached and it was confirmed that they would be teaching the same modules for both consecutive data collection periods and that their specific pedagogical approaches would not be changing. This actually was the observed case as the researcher confirmed teachers and pedagogical approaches for each cohort studied. Every module on the course involved lectures during the first term (the term in which data gathering was carried out) and practical sessions in later terms thus again, a standard approach was taken for all cohorts of students making up the target population. Given these assurances, the researcher felt comfortable that any changes in the planned research outcomes longitudinally (from cohort to cohort) would not be caused by changes in external influences for the research populations but could be reasonably claimed as a consequence of the planned and applied change in the research pedagogical approach.

The research initially addressed the relative outcomes in two consecutive cohorts of 120 first year engineering students. Cohort 1 (2016-17) was taught using a passive, didactic 'talk and chalk' style pedagogical approach giving little opportunity for dialogue or interaction within the lecture. Cohort 2 (2017-18) experienced a modified pedagogical approach that actively encouraged dialogue and interaction within the lecture environment through the use of a 'flipped classroom' employing case studies for deeper understanding. This exact approach was repeated in two cohorts of 'one year' taught masters postgraduate students, all students in these cohorts were new to the UK HE environment, as evidenced through their MSc applications and experience of traditional approaches taken in their respective countries of origin – circa 80% were of Chinese origin. Therefore, it was considered appropriate to use the MSc cohorts as 'new' to HE in the same way that first year undergraduates were new to HE teaching environments. All cohorts studied were taught by the researcher as part of their study course and were subject to normal teaching and assessment practices applied at the University of York. Questionnaires were delivered during class time and all participants were advised that their participation was voluntary, and that there was no reward or penalty for choosing to be involved or not. This reduced the likelihood of participants perceiving that they 'had to' be involved in the research but also had the effect of reducing the number of responses.

Students within these cohorts were evaluated using pre-teaching and post teaching surveys that were developed further for this research from those previously used by Jackson and Ward (2012) to ascertain respective changes in student attitudes and motivations towards engineering education. Previous research with small cohorts (CBL) used questions designed to discover how students felt about knowledge and skills required by engineers, how they approached their learning (learning style), how they thought about their learning (thinking style) and how confident they were in using existing skills or developing new ones. The tool from CBL studies was used as a pilot for this research during a previous module of the EdD programme. From feedback received the questionnaire was amended to reduce the number of required responses (i.e. it was a bit too long) and have the order of some of the questions changed to avoid confusion between current (self-esteem) and future (self-efficacy) capabilities. The questions on the importance of knowledge, skill and the ability to improve were designed by the author in conjunction with research team leader Prof Tony Ward for their 2012 study into CBL. These were found to be useful and already validated thus were used again here in an unchanged format. The thinking style questions utilised Gregorc's widely used index (DePorter, 1996) to check for a shift in the way students thought about their learning pre to post teaching. Using the same instrument for both cohort 1 and cohort 2 would indicate whether active teaching had a different impact on this aspect compared to passive teaching. Questions on Learning style visual/auditory/kinaesthetic (VAK) were modified from the previously validated work of Don Clark (2009), reducing the number of responses required but keeping the questions at a generic level to help respondents to understand what was being asked. There was some thought about re-phrasing the questions to be more relevant to engineering but after piloting the questionnaire, anecdotal evidence showed that most respondents felt the questions were straightforward so they were left in the generic form. Schwarzer and Jerusalem's (1995) scale was modified to evaluate self-esteem by ensuring the questions were suitable for engineering students i.e. largely problem solving and planning related. As is typical in self-efficacy research (Bandura 2006), self-efficacy items were developed by the researcher to make them specific to the research context and were based on engineering topics to help distinguish between what students believe they currently can do (self-esteem) and what they believe they are capable of doing in the future (self-efficacy). Additional questions on ethnicity were asked of the postgraduate groups and were found under initial analysis to be useful and so these were introduced in cohort 2 for undergraduates as well.

Results were quantitatively analysed to identify any differences within and between cohorts. A total of four semi-structured interviews were also held after the first cohort of quantitative data gathering to add qualitative meaning to the output as discussed in section 3.1. The original thinking had been to do six interviews (or up to 10%) with each cohort but after four, the information collected was very repetitive, so the researcher decided there was no point in further qualitative research during that cohort. In hindsight, this may have been premature and so six interviews were carried out after the second cohort of quantitative data analysis. A plan of the adopted research methodology has been discussed above (see Figure 3.1). The following repeated responses were received (i.e. at both pre and post data collections):

Undergraduate cohort 1 = 58/120 circa 48% response rate; cohort 2 = 50/110 circa 45%.

Postgraduate cohort 1: 39/42 circa 93% response rate; cohort 2 = 53/57 circa 93%

Pre and post teaching intervention questionnaires were administered in class to all cohorts (September to December 2016 – cohort 1, September to December 2017 – cohort 2) – see Appendices 4 and 5 for the questionnaires employed. After the first data collection (undergraduate cohort) and discussing the low response rate with the group, it was found that the low response rate was not due to the cover sheet instructions (i.e. not compulsory to complete) but rather the way in which it was administered by the researcher. With the very first questionnaire the researcher handed questionnaires out as students arrived and asked that they be completed and returned to the researcher either at the end of the lesson or by the end of the week – there were a number of ways in which the questionnaires could be returned but only 48% actually responded over the two data collections. This led the researcher to change collection approach and allow time to complete the questionnaires within the actual lesson at all other data collection instances resulting in a higher return rate for the second undergraduate cohort and both of the postgraduate cohorts.

Data from hard copy questionnaires were analysed using the Statistical Package for Social Science (SPSS) for individual changes in responses between pre-teaching and post teaching questionnaires. The ability to track individual responses depended on the number of responses collected and the willingness of participants to disclose their unique student identities. Analysis included tests for distribution of data – normally distributed data was analysed using parametric tests otherwise non-parametric tests were used (Saunders et al, 2009). Some factoring of responses was carried out to enable data to be analysed as a ‘scale’ thus enabling more accurate use of numerical ‘means’ or ‘medians’ in the case of non-normally distributed data. The strength of correlations between dependent and independent variables were assessed using mathematical coefficients depending upon the type of data category involved (e.g. Scalar, ordinal, interval or ratio) and any existing relationship between them (e.g. monotonic relationship can be identified where an increase in one variable results in either an increase or decrease in another). The researcher also considered differences in mean values between independent data groups to identify trends which proved to be a useful option where some respondents had failed to indicate their unique identifiers on at least one occasion and thus could not be directly tracked from pre-teaching to post teaching responses.

Qualitative data was recorded at source in a private office with respondents selected to ensure a mix of race, gender and ethnicity was included but where these respondents are identified in this report only through coding of individual responses. Quantitative data analysis relies on the collection of unique student identifiers and so the selection of interviewees was limited to selection of those students who could be identified as respondents to both pre-teaching and post teaching survey requests within their cohort. This was an unexpected restriction on the data collection activities. Research questions for the interview stages were developed on the basis of the quantitative findings (see Appendix 6). For example, questions were developed for interview to identify:

- Whether females are more comfortable with lecture materials.
- Whether males came to the sessions confident that their current abilities would help them cope with technology/design aspects.
- If males are more comfortable with technology engagement in general and that had made them overconfident at first.
- If the passage of time and experience impacted more on females especially in the measures for self-esteem that varied so much from pre to post teaching.

Qualitative data can be more explanatory than quantitative data and was useful as a measure of triangulation which is the use of two or more methods to collect data on the same topic (Cohen et al, 2007; Olsen, 2004). The coding of qualitative data was undertaken manually, due to the small number of interviews carried out, where common themes relevant for answering the research questions or identifying further research requirements were identified.

The data gathered was split into functional blocks:

Personal Information included a student identifier such that the researcher was able to track responses from pre-teaching to post teaching survey completion – a fundamental aspect of the research. Student age and gender was collected to allow analysis in these categories. Educational background was collected to allow their pre-university education location to be known as well as the major teaching style that they experienced during their previous highest level of qualification. Finally, in this section the respondent's ethnicity was collected as further research and the inclusion of the postgraduate cohort with a highly diverse ethnic content identified the potential need to be able to discern this aspect within individual respondents.

Knowledge – In this section respondents were asked to record how well they agreed with statements about the knowledge that an engineering student might need (7 items).

Skill/Ability – In this section respondents were asked to record how well they agreed with statements about the skills or abilities that an engineering student might need (9 items). The students were then asked whether they thought that the opportunity to improve some of these skills was important.

Self-esteem – In this section respondents were asked to indicate how well they agreed with statements about their current level of ability to carry out general activities (15 items).

Self-Efficacy – In this section respondents were asked to indicate how well they agreed with statements about their level of confidence that they would be able to carry out engineering activities if asked to do so (14 items).

Learning Style – In this section respondents were asked to select one statement that best described how they would approach a learning task (10 items). This allowed the researcher to determine the preferred learning style for each respondent at the time of the survey. It is noted that learning style may change anyway and thus any major changes from pre and post survey responses within an individual could be attributed to normal development. The intention was to compare such changes between cohorts and thus determine if there is any significance between their respective outputs that may be attributable to the change in teaching approach.

Thinking Style – In this section respondents were asked to select two from four words that best described themselves (15 sets of items). These words were then converted to a thinking style matrix using Statistical Package for the Social Sciences (SPSS) syntax (see Fig 3.3) that mapped the respondents' thinking style preferences to four generic thinking styles (see Figure 3.4 below) as developed by Gregorc (in Deporter, 1996). The four general categories of thinking style consisted of:

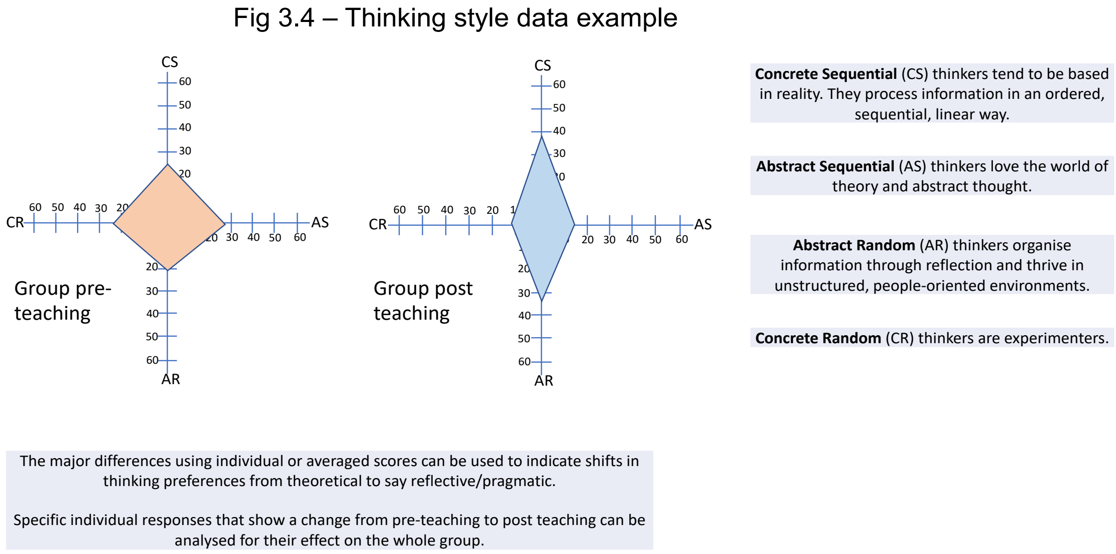
1) Concrete Sequential (CS) – realist;
2) Abstract Sequential (AS) – theorist;
3) Abstract Random (AR) – reflectivist; and
4) Concrete Random (CR) – experimentalist.

This provided an indication of any change from pre-teaching to post teaching in individual and group thinking style preference. Similarly to the learning style above, the intention is to compare inter-cohort results for any significant differences.

Fig 3.3 – Example of the SPSS conversion syntax for one set of words in Q21 (Pre and Post) and Q24 (Pre and Post plus all postgraduate surveys)

```
COMPUTE THINK_t1_1a=trunc(THINK1_t1/10).
EXECUTE.
COMPUTE THINK_t1_1b=THINK1_t1 - trunc(THINK1_t1/10)*10.
EXECUTE.
IF  (THINK_t1_1a = 1) THINK_t1_1a1=3.
EXECUTE.
IF  (THINK_t1_1a = 2) THINK_t1_1a1=4.
EXECUTE.
IF  (THINK_t1_1a = 3) THINK_t1_1a1=1.
EXECUTE.
IF  (THINK_t1_1a = 4) THINK_t1_1a1=2.
EXECUTE.
IF  (THINK_t1_1b = 1) THINK_t1_1b1=3.
EXECUTE.
IF  (THINK_t1_1b = 2) THINK_t1_1b1=4.
EXECUTE.
IF  (THINK_t1_1b = 3) THINK_t1_1b1=1.
EXECUTE.
IF  (THINK_t1_1b = 4) THINK_t1_1b1=2.
EXECUTE.
```

Fig 3.4 – Thinking Style Matrix (overall group data example)



In the example above we can see a shift in the group thinking style preference from pre-teaching to post teaching which would indicate a shift away from theoretical experimentation to reflection set in reality (more pragmatic after the event).

3.5 Ethical considerations

When trying to identify a pedagogical approach that might affect learners directly it is vital to consider any ethical aspects that may develop and ensure they are catered for from the outset using consent and confidentiality instruments. Careful consideration was given to ensure respondents, who could be identified through their unique student number, were not identifiable in the reported findings. This assurance to the target population helped to ensure they were more willing to participate and that outputs could be generalised more effectively. A key concern was that by approaching teaching in a different way the teacher did not in any way add their own bias and either consciously or unconsciously manipulate learners in their thinking i.e. skew the survey to give specific results. However, the previous discussion on bias in Section 2.3 (French, 2017), has suggested bias to be less important than it was thought to be at the start of this research.

The research required changes to the way students received their learning, in order to ascertain whether there were any subsequent changes in general self-efficacy, so careful control was needed in the focus of the measures. The research concentrated on the pedagogical approach but measured it by looking at student attitudes before and after the intervention similar to the CBL research by Jackson and Ward (2012). The CBL intervention was carefully controlled but as the final theoretical approach for this research required additional factors to be included in order to provide a more valid test then the research methods were given deeper ethical consideration and information/consent documentation produced (see Appendices 2 and 3). No ethical issues were identified for this research that could not be dealt with using standard consent-based procedures as prescribed by the Staffordshire University guide to ethical research. Ethical approval was obtained during the RDC1 process and the ethics approval form is in Appendix 7.

The research has addressed the above hypotheses, a timeline was drafted for the entire research process and can be found in Appendix 8 and the initial findings from the research will be presented in Chapters 4 and 5 before being discussed in Chapter 6 with overall conclusions and next steps/further research outlined in Chapter 7.

4. Quantitative Findings

This chapter sets out the findings of the quantitative elements within this research study. It starts with a short introductory section in Section 4.1 to set the context of and explain the method used for collecting data. The introductory section also sets out the research questions/hypotheses against which findings will be reported and, in Section 4.1.1, discusses the internal consistency and reliability of the scales used to collect data. Section 4.2 contains the descriptive statistics regarding frequencies for each cohort of undergraduate and postgraduate research. Findings for undergraduate and postgraduate participants can be found in Section 4.3 concerning data collections before (pre) and after (post) the use of passive and active teaching approaches. Aspects of descriptive, non-parametric and gender-based tests are included where appropriate for undergraduate and postgraduate cohorts. Section 4.4 gives a short Chapter summary.

4.1 Introduction

Looking at large data sets poses many issues but there are good practices aligned with quantitative research in particular that require the researcher to thoroughly inspect and clean data files before carrying out previously identified statistical tests. Indeed, the statistical tests that are valid will only be confirmed after such data cleanse and initial data evaluation are completed. Qualitative data collection was also carried out with all cohorts and this will be discussed along with further discussion of the findings for undergraduate and postgraduate cohorts within Chapter 5.

Data was collected on two occasions from two separate undergraduate and postgraduate student cohorts during the research making a total of four data collection events for undergraduate and four more for postgraduate respondents (see Appendices 4 and 5 for the research instruments used). Each student cohort was separated by their year of entry into the university and each cohort was sampled on two occasions. For the avoidance of confusion, these samples will be described as following:

Cohort 1 data collection events (normal or control group) collected data where a passive teaching approach was utilised. Pre and post teaching quantitative data collection for both undergraduate cohort 1 (n=33 pre and n=33 post teaching responses) and postgraduate cohort 1 (n=34 pre and n=32 post teaching responses) was carried out during the period September 2016 to December 2016 followed by qualitative data collection during January 2017. More details on response rates are contained in Section 4.2.

Cohort 2 data collection events (intervention group) collected data where an active teaching approach was utilised. Pre and post teaching quantitative data collection for both undergraduate cohort 2 (n=91 pre and n=50 post teaching responses) and postgraduate cohort 2 (n=53 pre and n=50 post teaching responses) was carried out during the period September 2017 to December 2017 followed by qualitative data collection during January/February 2018. As above, for more details on response rates see Section 4.2.

As a reminder, the main research question was refined to become two questions:

1) *The flipped classroom – does this dialogic and active teaching approach lead to a change in a learner's preferred learning or thinking style compared to a didactic, passive teaching approach?*
2) *Does a flipped classroom active approach enable students to be more confident in taking responsibility for their own learning and achievement compared to a didactic, passive teaching approach?*

Five discrete hypotheses were developed in the context of a traditional classroom passive teaching approach versus a flipped classroom active teaching approach as follows:

H1 – An active teaching approach impacts positively upon a learner's desire to learn when compared to a passive teaching approach.
H2 – A learner's preferred learning style can be affected by being exposed to an active teaching approach.
H3 – A learner's preferred thinking style can be affected by being exposed to an active teaching approach.
H4 – A learner's belief in their current abilities (self-esteem) is affected by being exposed to an active teaching approach.
H5 – The learner experiences a rise in their level of self-efficacy and takes more responsibility for their own learning when exposed to an active teaching approach.

As explained in the methodology (Chapter 3), firstly the data file was checked to ensure there were no errors in the data entry before identifying the characteristics of the sample followed by tests appropriate for the identified data distribution and any further tests suggested by initial analyses. The Shapiro-Wilk test is used as the most robust test for data sets of <50 respondents where it can be relied upon to correctly reject the null hypothesis of normality more often. The data were identified as non-normally distributed at all collections thus it is more appropriate to use non-parametric statistical hypothesis tests between the two samples collected for each cohort. Non-parametric tests eliminate distribution anomalies by converting the data into a ranked format that is then used for comparison. For repeated measures where participants are measured on two occasions, the Wilcoxon Signed Rank test is appropriate where having converted the scores to ranks, it compares the rankings from the first and second occasions (pre and post teaching) reporting the differences. For independent samples the Mann-Whitney U test is appropriate when looking for differences between groups on a continuous measure e.g. looking at whether males and females respond differently, converting again to ranks and comparing the rankings between groups. Analysing the findings from responses received, it was thought that gender may have played a part in some of the results so the possible impact through responses from different genders is explored. Also, the scales used were tested using Cronbach's Alpha for internal consistency and reliability (see Section 4.1.1).

This chapter sets out the data findings for cohorts 1 and 2, in narrative format splitting undergraduate and postgraduate responses as appropriate, with reference to further tables that can be found in Appendix 10, each table in the appendix will be numbered A10.xx for reference.

Data were collected for ethnicity from postgraduate cohorts to identify where ethnicity may have had an effect on student responses but there are no changes in any of the categories for either cohort thus no further findings are presented.

Data on the thinking style category will be presented in graphical format as it is easier to present any changes that have occurred using visual media rather than using narrative. Discussion on thinking style findings is included within the section and later in Chapter 5.

4.1.1 Internal Consistency and Reliability measures

Discussing internal consistency measures within the findings for each hypothesis may be confusing and so it is felt useful to explain here how the scales used in the quantitative data collection were validated and simply report any impact for each of the hypotheses as appropriate. The data for all cohorts at both pre and post teaching data collections has been tested for internal consistency/reliability of scale using the Cronbach Alpha test - additional exploration of possible anomalies and their respective analyses are presented in Chapter 5.

The values for Cronbach's Alpha (Cronbach, 1951) in educational/social research (see Table 4.1 below) indicate that values of Alpha above .70 are acceptable.

Table 4.1 – Internal consistency levels as per Cronbach (1951)

	Internal Consistency					
	Unacceptable	*Poor*	*Questionable*	*Acceptable*	*Good*	*Excellent*
Cronbach's alpha	< 0.5	≥ 0.5 to < 0.6	≥ 0.6 to < 0.7	≥ 0.7 to < 0.8	≥ 0.8 to < 0.9	≥ 0.9

4.1.1.1 The Importance of Knowledge Category

From the values shown in Table 4.2 below, it is suggested that there is an overall acceptable level of internal consistency within the 'importance of knowledge' scale for undergraduate cohort 1 where passive teaching was employed but a higher overall good level for cohort 2 where active teaching was employed.

Table 4.2 Undergraduate importance of knowledge for engineers – reliability statistic.

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.792	.804	7
	Post-teaching	.798	.806	7
Cohort 2 Active	Pre-teaching	.851	.856	7
	Post-teaching	.801	.799	7

Inter-item correlation tests show nothing to strongly indicate any influence has been due to the teaching approach, whether passive or active (Tables A10.27 and A10.28). Similarly, summary item statistics (Tables A10.29 and A10.30) and item total statistics (Tables A10.31 and A10.32) also indicate no major shift in student opinion regarding the importance of knowledge between data collections for either cohort.

Looking at the same information and tests for postgraduate cohorts shows a slightly different result for cohort 2 post teaching responses (Table 4.3).

Table 4.3 Postgraduate importance of knowledge for engineers – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.943	.944	7
	Post-teaching	.832	.834	7
Cohort 2 Active	Pre-teaching	.893	.894	7
	Post-teaching	.527	.536	7

Inspection of inter-item correlation shows values are all positive, indicating measures of the same underlying scale, and supporting the alpha result for cohort 1 (Table A10.82). There are weaker correlations between items for cohort 1 but nothing to indicate any influence due to the teaching approach. Cohort 2 inter-item correlations (Table A10.83), indicates all values to be positive before teaching. However, at the post teaching data collection the measures show very much weaker relationships, indeed two relationships ('accounting & finance' to 'human resources management' and 'legal aspects' to 'human resources management') show negative values indicating no clear relationship. Summary item statistics (Tables A10.84 and A10.85) confirm the above results and indicate a lowering in student opinion of the importance of knowledge for engineers during the active teaching intervention.

From Table A10.86 the 'corrected item-total correlation' column indicates each of the measures for cohort 1 is consistent with the scale as a whole (i.e. > .3) and by removing the item from the Cronbach's Alpha calculation shows one value for pre-teaching that is higher than the overall Alpha value (Design & Production = .949 is > .943). For cohort 2, Table A10.87 'corrected item-total correlation' column indicates each measure is consistent with the scale as a whole (i.e. > .3) for pre-teaching and by removing the item from the Cronbach's Alpha calculation shows all values lower than the overall Alpha (.893). However, one value for post teaching is higher than the overall Alpha value ('human resource management' = .540 is > .527). Inter-item correlation analysis, show the 'human resources management' item has quite low correlation scores to the other 6 items. It is unclear why there is poor overall correlation in these scale items for cohort 2 post teaching responses.

4.1.1.2 The Importance of Skills Category

Looking at the same tests for the importance of skills for undergraduates (Table 4.4 we see a rise in internal consistency for cohort 1 but a slight drop for cohort 2. Inter-item correlations and summary item statistics again indicate no major shift for either cohort (Tables A10.33a to A10.35b undergraduate).

Table 4.4 Undergraduate importance of skills in engineers – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.838	.836	9
	Post-teaching	.951	.951	9
Cohort 2 Active	Pre-teaching	.888	.891	9
	Post-teaching	.850	.852	9

Tests for responses regarding student's views of the importance of developing certain skills as engineers and relevant results for postgraduate are shown in the Table 4.5.

Table 4.5 Postgraduate importance of skills in engineers – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.944	.944	9
	Post-teaching	.768	.771	9
Cohort 2 Active	Pre-teaching	.924	.927	9
	Post-teaching	.749	.747	9

As can be seen, the reliability statistic for this set of questions shows excellent internal consistency moving to acceptable internal consistency for both cohort responses. Measures were consistent with the scale as a whole (i.e. > .3) for cohort 1 with the exception of one item after the teaching, 'using discussion to investigate an issue' shows a negative correlation to 'be creative'. The low result for the 'discussion' item has also resulted in the alpha score being higher (.775 is > .768), its paired correlation item of 'be creative' does not show the same effect, thus the lack of discussion in the class environment may have led to this result (Table A10.88). Two items for cohort 2, both post teaching, 'communicate effectively' and 'using discussion to investigate an issue' show negative correlations (Table A10.89) but neither has a higher alpha score when removed thus no impact is evident from these items (Tables A10.91 and A10.92). There are no other indications as to why the internal consistency ratings dropped.

4.1.1.3 The Self-Esteem Category

The self-esteem scale measures for undergraduates (Table 4.6 below) also show no statistically significant changes (see also Tables A10.36a to A10.41d) although for cohort 2 the consistency measure stays in the good category after the teaching intervention. Some negative correlations are shown for each cohort tending to indicate that some of the measures are not actually measuring self-esteem on the same scale as other items. Corrected item totals correlations for the items ‘sticking to my plans’ and ‘sticking to my plans 2’ remain below 0.3 for cohort 1. For cohort 2 there is a similar pattern for these items with the addition of the item ‘being calm under stress’ and with the item ‘sticking to my plans 2’ post teaching rising above .3 for the first time to .404 indicating a more robust correlation with other items in the scale. This contradicts the correlation for ‘sticking to my plans’ and is considered to be a one-off result with no significant meaning.

Table 4.6 Undergraduate view of self-esteem – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.834	.839	15
	Post-teaching	.742	.777	15
Cohort 2 Active	Pre-teaching	.832	.839	15
	Post-teaching	.804	.809	15

The self-esteem scale measures for postgraduates are largely unsurprising (Table 4.7).

Table 4.7 Postgraduate view of self-esteem – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.774	.776	15
	Post-teaching	.820	.822	15
Cohort 2 Active	Pre-teaching	.872	.879	15
	Post-teaching	.773	.786	15

Table 4.7 shows acceptable internal consistency moving to good for cohort 1 but the opposite for cohort 2. The change is relatively small, some impact may be attributable for cohort 1 to the item ‘acceptance of challenges’ and for cohort 2 items ‘problem solving’ and ‘relying on oneself’. No other effects were evident (Tables A10.93 to A10.97).

4.1.1.4 The Self-Efficacy Category

In Table 4.8, self-efficacy scale measures show an overall drop in internal consistency scores for undergraduate cohort 1. However, the reliability statistic for cohort 2 shows poor internal consistency pre-teaching moving to good internal consistency post teaching. Investigating the poor internal consistency pre-teaching it can be traced to the same response item as we saw in descriptive statistical tests, ‘remember engineering design lecture content’ which, if removed, takes the reliability value to .803 and results in no negative correlations or other anomalies. (see also Tables A10.42a to A10.47d).

Table 4.8 Undergraduate view of self-efficacy – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.946	.946	14
	Post-teaching	.889	.893	14
Cohort 2 Active	Pre-teaching	.523	.803	14
	Post-teaching	.864	.867	14

Overall good internal consistency is therefore evident in all undergraduate categories once any outliers are removed. The self-efficacy scale measures for postgraduate respondents are similar showing an overall rise in relative internal consistency score for both cohorts (Table 4.9).

Table 4.9 Postgraduate view of self-efficacy – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.838	.841	14
	Post-teaching	.855	.850	14
Cohort 2 Active	Pre-teaching	.851	.856	14
	Post-teaching	.865	.862	14

In Table 4.9, the reliability statistic for the self-efficacy set of questions shows good internal consistency moving to slightly higher but still good internal consistency for both cohorts. Corrected item-total correlations are all above .3 for cohort 1 except for ‘finish reports or assignments on time’ pre-teaching data collection but is corrected by the end of teaching and ‘plan/organise your workload’ post teaching which may be due to imminent assignment submission deadlines approaching. For cohort 2 pre-teaching, the item ‘using search engines’ has very weak correlation and supports the inter-item correlation results for a number of items. This is corrected post teaching but the item ‘finish reports / assignments on time’ is weak and may reflect the same fears as those seen for cohort 1. Despite these results there are no clear indications of specific issues with any of the items in the scale (Tables A10.98 to A10.102).

4.1.1.5 The Learning Style Category

Reliability for the learning styles scale was checked with the following results shown in Tables 4.10 (undergraduate) and 4.11 (postgraduate).

Table 4.10 Undergraduate view of learning style preference – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.622	.628	10
	Post-teaching	.674	.685	10
Cohort 2 Active	Pre-teaching	.402	.392	10
	Post-teaching	.561	.564	10

We see questionable reliability for undergraduate cohort 1 at both data collections and unacceptable reliability pre-teaching rising to poor reliability post teaching for cohort 2.

The reliability statistics in Table 4.11 show a questionable reliability overall for cohort 1 but an unacceptable reliability for cohort 2, indeed the negative value for post teaching results violates the reliability model. Checks of scale data and item codings for changed aspects or missing values for postgraduate cohort 1 and cohort 2 show no differences in the data analysed so this result is unexpected and inexplicable. Tables A10.103 to A10.107 are reproduced to present the data analyses output and these confirm the measures for postgraduate cohort 2 are not consistent and thus can only be taken as an indicator.

Table 4.11 Postgraduate view of learning style preference – reliability statistic

Cohort	Data Set	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Cohort 1 Passive	Pre-teaching	.586	.580	10
	Post-teaching	.610	.601	10
Cohort 2 Active	Pre-teaching	.111	.136	10
	Post-teaching	-.012	-.090	10

4.2 Frequency Statistics Cohorts 1 & 2

Frequency and descriptive statistics outline the characteristics of the sample and help position the data collected. For smaller cohorts such as those in this research the whole population was invited to respond at each data collection, the following tables outline actual responses collected.

Undergraduate Cohorts

Undergraduate Cohort 1 (Table 4.12 below) saw a total of 33 valid responses (22% of potential responses) received at each data collection point, eight of these were identifiable as repeated responses at both pre and post teaching data collections. The low percentage response rate is explained by the method of data collection. Distribution and return of questionnaires for pre-teaching was carried out during the first lecture but insufficient time was allocated for respondents to complete them and so many were unusable. This was addressed for post teaching and response rates increased dramatically (circa 80% usable) but the attendance at the final lecture was poor – a factor outside of the control of the researcher. Poor attendance means there is a possibility that the respondents, despite being within the target population, may not be a fully representative sample. Tests for data normality show all categories to be non-normally distributed (see Tables A10.1a to A10.6b) but some are reported because some changes in distribution of data by gender are identified.

Table 4.12 Undergraduate respondent totals Cohort 1.

		Pre-teaching	Valid Percent Pre-teaching	Post teaching	Valid Percent Post teaching
Age at last birthday	18-24	30	90.9	30	90.1
	25-34	1	3.03	3	9.9
	35-44	1	3.03	-	-
	55-64	1	3.03	-	-
	Total	33	100.0	33	100.0
Gender	Male	25	75.8	26	78.8
	Female	8	24.2	7	21.2
	Total	33	100.0	33	100.0
School	England	30	90.9	27	81.8
	Wales	-		2	6.1
	India	1	3.0	-	-
	Other	2	6.1	4	12.1
	Total	33	100.0	33	100.0

Undergraduate Cohort 2 (Table 4.13 below) saw 91 valid responses for pre-teaching (75.8% of potential responses) and 50 valid responses for post teaching (41.7%). Repeated responses at both data collections are identified as n = 44. Overall it can be seen that the differences in the make-up of respondents (age, gender, schooling, experience of teaching style) between pre and post data collections are small and thus both sets can be said to represent similar populations even though response rates are lower post teaching.

Table 4.13 Undergraduate respondent totals Cohort 2.

		Pre-teaching	Valid Percent Pre-teaching	Post teaching	Valid Percent Post teaching
Age	18-24	87	95.6	44	88
	25-34	4	4.4	6	12
	Total	91	100	50	100
Gender	Male	83	91.2	42	85.7
	Female	8	8.8	7	14.3
	Total	91	100	49	100
School	England	75	82.4	42	84
	Wales	1	1.1	-	-
	China	6	6.6	4	8
	India	1	1.1	-	-
	Other	8	8.8	4	8
	Total	91	100	50	100
Taught Style	Passive	29	32.6	16	32.7
	Active	60	67.4	33	67.3
	Total	89	100	49	100

A characteristic not collected for undergraduate cohort 1 was ethnicity which could have impacted some of the findings – this was corrected for cohort 2 (see Table 4.14).

Table 4.14 Ethnic groupings undergraduate cohort 2

		Pre-teaching	Valid Percent Pre-teaching	Post teaching	Valid Percent Post teaching
Valid	British	64	70.3	36	73.5
	Other white background	9	9.9	5	10.2
	White and Asian	1	1.1	-	-
	Other mixed or multiple background	3	3.3	1	2
	Indian	3	3.3	2	4.1
	Chinese	7	7.7	4	8.2
	Other Asian background	1	1.1	1	2
	African	2	2.2	-	-
	Any other ethnic group	1	1.1	-	-
	Total	91	100	49	100

As expected, the age profile for first year undergraduates at all data collections is highly skewed towards the lower end and because of this it is not possible to obtain meaningful analyses through age comparisons for these data.

In engineering subjects at higher education establishments in the UK it is not surprising to see a majority of male respondents and the gender balance shown in Tables 4.1 and 4.2 is representative of the normal profile of high school/secondary school education background for York University undergraduates. This pattern was replicated in data collections from each undergraduate cohort.

The split of undergraduate respondents per data collection as shown indicates that circa 90% of responses were from 18-24 year olds at each collection with almost the same proportions of males and females in each case. If we take England and Wales together we see once again an almost equal representation of UK educated respondents in each data set.

An interesting output is the high percentage of undergraduate respondents in cohort 2 who claim to have experienced an active teaching style before coming to university. This may also have an impact on results but unfortunately cannot be directly compared against cohort 1 as this datum was not collected.

Postgraduate Cohorts

Postgraduate cohort 1 (Table 4.15 below) saw a total of 39 valid individual responses (95% of potential responses) received overall. Some responses were only submitted during one of the data collection points thus the number of responses at each data collection point are different pre-teaching cohort 1 (n = 34, 83%) and post teaching cohort 1 (n = 32, 78%), 27 of these (66%) were identifiable as repeated responses at both pre and post teaching data collections.

Tests for data normality are reported (see A10.48a to A10.53b) and all data are non-normally distributed for cohort 1 and 2 responses. There are some changes in distribution of data by gender identified that will be detailed later in this chapter within the hypothesis findings sections.

Table 4.15 Postgraduate respondent totals cohort 1.

		Pre-teaching	Valid Percent Pre-teaching	Post teaching	Valid Percent Post teaching
Age at last birthday	18-24	26	76.5	23	71.9
	25-34	7	20.6	8	25
	35-44	1	2.9	1	3.1
	Total	34	100.0	32	100.0
Gender	Male	20	58.8	22	68.75
	Female	14	41.2	10	31.25
	Total	34	100.0	32	100.0
School	England	1	2.9	1	3.1
	China	25	73.53	27	84.4
	Other	8	23.53	4	12.5
	Total	34	100.0	32	100.0
Previous Education style	Passive	20	58.8	21	65.6
	Active	14	41.2	11	34.4
	Total	34	100.0	32	100.0

Table 4.16 Postgraduate respondent totals cohort 2.

		Pre-teaching	Valid Percent Pre-teaching	Post teaching	Valid Percent Post teaching
Age	18-24	42	74.4	40	80.0
	25-34	9	23.0	9	18.0
	35-44	2	2.6	1	2.0
	Total	53	100.0	50	100.0
Gender	Male	30	56.6	30	60.0
	Female	23	43.4	20	40.0
	Total	53	100.0	50	100.0
School	England	1	1.9	1	2.0
	China	43	81.1	40	80.0
	India	1	1.9	1	2.0
	Other	8	15.1	8	16.0
	Total	53	100.0	50	100.0
Previous Education style	Passive	33	64.7	33	66.0
	Active	18	35.3	17	34.0
	Total	51	100.0	50	100.0

Postgraduate cohort 2 saw a total of 53/57 valid responses (92.3%) received pre-teaching and n = 50/57 (87.7%) at post teaching data collection points, 47 of these (82.5%) were identifiable as repeated responses. Frequency numbers are reported below in Table 4.16.

The age profile for postgraduates as expected is skewed towards the lower end due to their coming largely from undergraduate studies into MSc study to top up their qualifications. In engineering subjects at higher education establishments in the UK it is not surprising to see a majority of male respondents but as this is a postgraduate group, almost entirely made up of international students, it is evident that there are more females in the group than for an equivalent UK group. Tables 4.15 and 4.16 are representative of the normal profile of education background for York university postgraduates. The split of respondents per data collection indicates that an almost equal number of 18-24 year-olds responded to each data collection with a similar split between genders.

Schooling is as expected given the ethnicity but given that the vast majority of respondents are Chinese and that the education system in China is known to be largely passive, the passive/active teaching experience split is different to that expected. It is surprising to see such a large proportion of respondents claiming to have experience of active teaching. However, the proportions are similar for all data collections and thus represent each cohort appropriately.

Table 4.17 Postgraduate respondent previous education level combined cohort 1.

Combined responses		Frequency	Valid Percent	Cumulative Percent
Previous Education level	Bachelors	31	79.5	79.5
	Masters	8	20.5	100.0
	Total	39	100.0	

Many respondents claim to already have achieved a masters level qualification. From the researchers experience in vetting the applications, this would be a higher percentage than experienced whilst making offers. Table 4.17 shows the combined responses from a cohort that totalled 41, over both data collections 39 separate responses were received and are reported. Data were checked and where paired responses are available, the response is identical in all cases indicating the students did not answer randomly and that the data are considered to be accurate.

Table 4.18 sets out cohort 2 submission data where 92.3% of the cohort actually responded to the pre-teaching data collection and the post teaching responses match those given before teaching.

Table 4.18 Postgraduate respondent previous education level totals cohort 2.

		Frequency pre-teaching	Valid % pre-teaching	Frequency post teaching	Valid % post teaching
Previous Education level	Bachelors	49	92.5	48	96.0
	Masters	4	7.5	2	4.0
	Total	53	100.0	50	100.0

The ethnic grouping split of postgraduate respondents (shown in Tables 4.19 and 4.20 below) follows the expected pattern.

Table 4.19 Postgraduate respondent ethnic grouping totals cohort 1.

Combined responses		Overall Frequency	Valid Percent	Cumulative Percent
Ethnic Grouping	White UK	2	5.1	5.1
	White other	2	5.1	10.2
	Mixed other	1	2.6	12.8
	Asian Chinese	30	76.9	89.7
	Asian other	3	7.7	97.4
	Black other	1	2.6	100
	Total	39	100	

Table 4.20 Postgraduate respondent ethnic grouping totals cohort 2.

		Frequency pre-teaching	Valid Percent pre-teaching	Frequency post teaching	Valid Percent post teaching
Ethnic Grouping	White other	3	5.7	3	6.0
	Mixed Asian	1	1.9		
	Mixed other	2	3.8	2	4.0
	Asian Indian	1	1.9	1	2.0
	Asian Chinese	43	81.1	41	82.0
	Asian other			1	2.0
	Black African	1	1.9	1	2.0
	Black other	2	3.8	1	2.0
	Total	53	100.0	50	100.0

All data were analysed using descriptive tests for means, standard deviation, skewness and kurtosis alongside tests of normal distribution (Shapiro-Wilk) and associated statistical tests. Section 2.3 and mainly Section 3.4 explains the scales used for quantitative data gathering and for this research the scales were further developed to ascertain information on the following categories:

a) The importance of knowledge for engineers;
b) The importance of skills for engineers;
c) The importance of improvement;
d) Self-esteem;
e) Self-efficacy; and
f) Learning style preference.

However, because neither the cohort 1 nor cohort 2 samples for both undergraduate and postgraduate populations can be definitely shown to follow a normal distribution it is more appropriate to use a non-parametric statistical hypothesis test between the two respective pre and post teaching samples. The tests used were the Wilcoxon Signed Rank test for repeated measures plus the Mann-Whitney U test for independent samples of groups.

Further tests have also been carried out using paired sample t-distributions where confirmation of result was thought to be appropriate. All results will be presented under their respective hypothesis test headings by population, with a brief description of the findings within and between cohorts as appropriate. Further discussion and analysis of all findings, including findings from interview, will be presented in Chapter 5.

4.3 Undergraduate findings by Hypothesis

Findings for each of the five hypotheses are presented in this section, undergraduate findings will be followed by postgraduate findings in all cases.

4.3.1 Tests for Hypothesis 1 – Active versus Passive teaching.

H1 – An active teaching approach impacts positively upon a learner's desire to learn when compared to a passive teaching approach.

Descriptive tables are produced to check for skewness and kurtosis indicating any potential bias given such a small sample size. Each category (and the items within them) was analysed in this way, along with their respective tests of normality, all were assessed using raw data, significance measures and normal probability (Q-Q plots) to test actual distributions.

Undergraduate Cohorts – Importance of Knowledge

Table 4.21 below shows that the mean and standard deviation measures for the 'importance of knowledge' category are almost the same from pre to post teaching survey but some of the relative positioning and concentration of data show differences that may be significant although the small data set could affect the latter. Skewness has been affected positively (lower scores) from pre to post teaching survey in four items and negatively (higher scores) in three items. Kurtosis has also been affected in many items – more negative shows a tendency towards flatter distribution (more responses in the extremes) where more positive shows a tendency for answers to be clustered towards a central response. For example, on a scale of 1 to 5, more respondents selecting a scale value of 3 or 4 rather than being spread across all valid scale values.

Table 4.21 Cohort 1 Undergraduate responses of the importance of existing knowledge split by data collection.

Importance of Knowledge	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Accounting & Finance	Pre	3.33	.990	-.328	-.376
Accounting & Finance	Post	3.27	.911	-.061	-.976
Sales and Marketing	Pre	3.52	.795	-.053	-.280
Sales and Marketing	Post	3.27	.977	-.594	.229
Human Resource Management	Pre	3.55	.869	-1.060	1.290
Human Resource Management	Post	3.39	.899	-.622	.360
Project planning	Pre	4.55	.617	-1.032	.140
Project planning	Post	4.18	.808	-.731	.075
Design and Production	Pre	4.64	.549	-1.188	.519
Design and Production	Post	4.48	.755	-1.569	2.475
Quality Management	Pre	4.33	.645	-.440	-.601
Quality Management	Post	4.33	.692	-.557	-.712
Legal aspects	Pre	3.67	.924	-.777	1.026
Legal aspects	Post	3.85	1.064	-1.005	.515

It is interesting to note that given this cohort were exposed to a passive teaching approach in a design-based project module (Engineering Design), it is evident from Table 4.21 that the mean for the item “Importance of Design and Production” has fallen slightly when it would be expected to rise, whilst the responses are more clustered (kurtosis has risen a lot). This was compared with the actively taught cohort where the mean score for the same item also fell slightly but the kurtosis has fallen dramatically indicating a far greater spread of responses where active teaching was experienced (Table 4.22). This greater spread is also noticeable in the item ‘project planning’, another area where the concentration of responses would be expected to increase rather than decrease. These results are a little unexpected in that the Kurtosis shows a much more neutral response after the active teaching intervention compared with the extremely polarised response pre-teaching.

Table 4.22 Cohort 2 Undergraduate responses of the importance of existing knowledge split by data collection.

	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Accounting & Finance	Pre	3.58	.887	-.538	.422
Accounting & Finance	Post	3.70	.814	-.094	-.457
Sales and Marketing	Pre	3.50	.974	-.559	.318
Sales and Marketing	Post	3.60	.857	.081	-.629
Human Resource Management	Pre	3.62	.829	-.642	1.063
Human Resource Management	Post	3.62	1.008	-.654	.315
Project planning	Pre	4.58	.734	-2.803	10.926
Project planning	Post	4.56	.644	-1.188	.330
Design and Production	Pre	4.63	.726	-3.093	12.501
Design and Production	Post	4.56	.675	-1.264	.368
Quality Management	Pre	4.30	.827	-1.588	3.911
Quality Management	Post	4.38	.697	-1.060	1.408
Legal aspects	Pre	3.80	.974	-.705	.241
Legal aspects	Post	4.00	.904	-.692	-.147

Postgraduate Cohorts – Importance of Knowledge

For postgraduate cohorts in the category the 'importance of knowledge', means all rose slightly and standard deviation measures all changed in the same way for both cohorts. Skewness was affected negatively (more positive scores) for both cohorts which, after investigation, was due to more median scores. Kurtosis was also affected the same for both cohorts with more negative scores in all items – showing a tendency towards a flatter distribution and this supports the other results for mean, standard deviation and skew (Tables A10.54a and A10.54b). One can notice a wider spread of responses from cohort 2, especially for kurtosis measures but this may be cohort specific.

All Cohorts – Importance of Skills

For the 'importance of skills in engineers' category (Table A10.7a and A10.7b) the mean scores for undergraduate cohorts are above 4 in all data collections thus only minor changes are evident and not significant regards the impact of teaching style on the students. The 'importance of skills' postgraduate category items are presented in Tables A10.55a and A10.55b showing a slightly higher mean, tighter spread of responses, more positive Skew and a more negative Kurtosis for all items at both data collections (with the exception of the 'produce quality reports' item for cohort 1). Nothing to suggest any different impact from the use of an active teaching approach with postgraduate cohort 2.

All Cohorts – Importance of Improvement

There are no indicators that the teaching style has had any impact on the undergraduate students' views of the importance of being able to improve. Postgraduate students opinions on the opportunity to improve were very positive overall but cohort 1 saw a slight drop in mean value compared to cohort 2 where the mean rose slightly (Table A10.56).

All Cohorts – Self-Esteem

For the self-esteem category, undergraduate mean scores have all risen (some only very slightly) for cohort 1 tending to indicate more belief in their current capabilities. For cohort 2 the mean scores remained very close, some rising and some falling very slightly. Standard deviation, Skewness and Kurtosis measures for both cohorts vary quite a lot but there are no obvious patterns evident (see Table A10.8a and A10.8b). No obvious impact from the change in teaching style between cohorts for undergraduates.

The same effect is seen for postgraduate cohorts as they mirror the undergraduate results with no obvious trends (Table A10.57a and A10.57b). Where there are some larger changes in mean scores for postgraduate cohort 2, 'investing the appropriate effort' and 'sticking to my plans 2', examining the responses does not show any dramatic differences that might indicate a change from normal to highly polarised. There is no clear indication that belief in their current capabilities has changed due to active teaching.

All Cohorts – Self-efficacy

For the self-efficacy category for undergraduate cohort 1, differences between the means (see Table A10.9a) and their respective 5% trim values are minimal showing no impact from extreme values. However, four items 'finish reports', 'use the library', remember engineering design lectures' and 'remember engineering design practical' show a reduced mean while all others show rises or remain the same. In undergraduate cohort 2 (Table A10.9b) we see a similar pattern overall with mean scores being very slightly higher but there is one large anomaly for the item ‘remember engineering design lecture content’ with a large change pre to post teaching for cohort 2. This can be explained by one outlier in pre-teaching responses that when removed corrects this aspect and then shows no impact through different teaching approaches.

Measures for self-efficacy in postgraduate cohorts show no major changes in mean values, most rise slightly but some items fall slightly, probably due to imminent assignment deadlines. No extreme values are evident for either cohort and again no evidence of any impact through active teaching (Tables A10.58a and A10.58b).

In summary from descriptive statistics, there are some indications that surprise the researcher regarding mean values falling when expected to rise but there are no clear indications of any different impact on students through the use of an active rather than a passive teaching approach. Indeed, there was not even the expected rise in self-esteem for either undergraduate or postgraduate cohort 2 where active teaching was employed.

Gender differences – Undergraduate Cohorts

Tests for the distribution of data using descriptive statistics showed mainly non-normally distributed data in all cases but it was thought that there may be gender differences as some undergraduate female responses were normally distributed. Testing for gender differences indicated that undergraduate male respondents exhibited a non-normally distributed response profile at all data collections for both cohorts. However, there were some changes for female respondents in both cohorts. Results are summarised in Table 4.23 below and show only those items that changed for female respondents. See also Tables A10.11a to A10.15b.

Table 4.23 Normality tests pre to post teaching for undergraduate females

Category	Category Item	Shapiro-Wilk Significance Statistic (Females)			
		Cohort 1 (Passive)		***Cohort 2 (Active)***	
		Pre-teaching	*Post teaching*	*Pre-teaching*	*Post teaching*
Importance of Knowledge in Engineers	Accounting & Finance	.056	.000	Normal Distribution	
	Sales and Marketing	Non-Normal Distribution		.002	.099
	Quality Management	Non-Normal Distribution		.006	.086
	Legal aspects	.067	.006	Normal Distribution	
Importance of Skills in Engineers	Give effective presentations	.408	.000	Normal Distribution	
	Produce quality reports	.004	.086	Normal Distribution	
	Be creative	Non-Normal Distribution		.000	.062
	Formulate good questions	Non-Normal Distribution		.001	.086
	Use discussion to investigate	.015	.099	.001	.099
Self-Esteem	Problem solving	.036	.456	.056	.008
	Achieving aims/goals	Normal Distribution		.120	.001
	Deal with unexpected events	Non-Normal Distribution		.037	.086
	Resourcefulness	.015	.144	.037	.086
	Relying on oneself	Normal Distribution		.067	.008
	Investing appropriate effort	Non-Normal Distribution		.000	.262
	Sticking to my plans	.001	.429	.324	.000
	Generating solutions	.001	.062	.056	.001
	Coping with uncertainty	.007	.064	Non-Normal Distribution	
	Acceptance of challenges	.324	.012	Non-Normal Distribution	
	Thinking around a problem	.001	.609	Non-Normal Distribution	
	Making sensible judgments	Normal Distribution		.000	.609
	Sticking to my plans 2	Normal Distribution		.000	.294
Self-Efficacy	Finish reports…on time	Normal Distribution		.056	.000
	Taking class notes…	.114	.030	.056	.001
	Remember Eng Design Lecture	Normal Distribution		.037	.482
	Motivate self to study Eng	Normal Distribution		.067	.001
	Join in class discussions	Normal Distribution		.324	.000
	Design/construct experiment…	Normal Distribution		.054	.001
	Document technical procedures	.046	.059	.522	.020
Learning style preference	Operate new equipment	Normal Distribution		.018	.062
	Teaching something new	.000	.086	.056	.001
	Choosing a holiday	Normal Distribution		.000	.062
	When I concentrate	.056	.000	.067	.020
	When learning a new skill	Normal Distribution		.056	.001

Further tests for significant differences in the distribution of data using the Mann-Whitney U test to compare median scores indicate only five significant results for cohort 1 and none for cohort 2. Table 4.24 below summarises these results and it should be noted that the appropriate results for cohort 2 are reproduced for comparative purposes only. Results indicate that passive teaching may have affected males and females differently but that active teaching did not. Indeed, active teaching seems to have made little statistically significant difference at all when comparing across gender at undergraduate levels. See also Tables A10.16a to A10.19b.

Table 4.24 Hypothesis tests of undergraduate gender differences.

Self-Efficacy Category Item	**Mann-Whitney U**			
	Cohort 1		**Cohort 2**	
	Pre	**Post**	**Pre**	**Post**
Concentrate on tech engineering subjects	.036	.682	.322	.510
Remember 'Engineering Design' lecture content	.176	.014	.771	.791
Remember 'Engineering Design' practical session outputs	.061	.031	.549	.529
Learning Style Category Item	**Mann-Whitney U**			
	Cohort 1		**Cohort 2**	
	Pre	**Post**	**Pre**	**Post**
If I am teaching someone something new I tend to…	.004	.531	.473	.944
If I were out shopping for clothes I would tend to…	.041	.288	.985	.475

Gender differences – Postgraduate Cohorts

Postgraduate results are very similar to the above. Tests indicated that male respondents exhibited a non-normally distributed response profile at all data collections for both cohorts as did females for cohort 2. However, there were some changes for female respondents in cohort 1, results are summarised in Table 4.25 below and show only those items that changed for female respondents. See also Tables A10.60a to A10.63b.

Table 4.25 Normality tests showing differences between data collections for PG females

Category	Category Item	Shapiro-Wilk Significance Statistic (Females)			
		Cohort 1 (Passive)		***Cohort 2 (Active)***	
		Pre	*Post*	*Pre*	*Post*
Importance of Knowledge	Legal Aspects	.079	.025	.000	.000
Self-Esteem	Relying on oneself	.078	.000	.000	.005
	Being calm under stress	.062	.036	.001	.002
Self-Efficacy	Take class notes…	.040	.149	.000	.009
	Lead a technical team…	.088	.036	.005	.000

Further tests for significant differences in the distribution of data using the Mann-Whitney U test to compare median scores indicate only four significant results for cohort 1 and four for cohort 2. Table 4.26 below summarises these results. Results indicate that both passive and active teaching may have affected males and females differently. See also Tables A10.65a to A10.68b.

Table 4.26 Hypothesis tests of postgraduate gender differences.

Self-Esteem Category Item	**Mann-Whitney U**			
	Cohort 1		**Cohort 2**	
	Pre	**Post**	**Pre**	**Post**
Resourcefulness	.007	.433	.780	.262
Sticking to my plans	.027	.495	1.000	.697
Sticking to my plans 2	.020	.596	.985	.857
Achieving aims/goals	.138	.596	.117	.004
Self-Efficacy Category Item	**Mann-Whitney U**			
	Cohort 1		**Cohort 2**	
	Pre	**Post**	**Pre**	**Post**
Remember 'Engineering Design' lecture content	.017	.298	.300	.752
Take part in class based engineering or technical discussions	.231	.596	.004	.136
Design and construct an experiment that maintains precisely specified conditions	.129	.375	.014	.916
Document technical procedures so that someone else could use them to produce the same result	.090	.463	.018	.296

Age Related Differences

These tests were only carried out with the postgraduate cohorts due to the lack of age spread amongst undergraduates. Tests of normality for responses received within the importance of knowledge category data show some changes during postgraduate cohort 1. Table 4.27 below shows the changed distribution of results, only respondents in the 25-34 year old bracket showed any change and only in these items. Accounting and Finance plus Quality Management items move from normal to non-normally distributed where HRM and Project planning show an opposite movement.

Table 4.27 Postgraduate responses of the importance of existing knowledge split by age and data collection cohort 1.

Item and age at last birthday	Age at last birthday	Shapiro-Wilk Significance	
		Pre-teaching	Post teaching
Accounting & Finance	25-34	.101	.001
Human Resource Management	25-34	.031	.212
Project planning	25-34	.031	.212
Quality Management	25-34	.212	.000

For cohort 2 tests of normality within the importance of knowledge category for Age show no changes pre-teaching to post teaching. See Tables A10.70a and A10.70b

Split by age for the importance of skills category for cohort 1, all items show a rise in the way skills are seen to be important, for 25-34 year olds there are four in particular that indicate a greater consensus (Table 4.28) - one includes a similar change for 18-24 year olds as well ('design and produce products/services'). The item 'solve problems' shows a wider spread of opinion for 25-34 year olds after using a passive teaching approach. Tables A10.71a and A10.71b have all results. The only change for the importance of skills category by age group evident for cohort 2 was in the item 'use discussion to investigate issues' with more consensus of opinion (Pre-teaching = .091 and Post teaching = .012).

Table 4.28 Normality tests postgraduate cohort 1 of the importance of skills split by age.

Item in the importance of skills category	Age at last birthday	Shapiro-Wilk Significance	
		Pre-teaching	Post teaching
Give effective presentations	18-24	.000	.000
	25-34	.421	.001
Produce quality reports	18-24	.000	.003
	25-34	.820	.001
Solve problems	18-24	.000	.000
	25-34	.033	.101
Design and produce products/services	18-24	.053	.000
	25-34	.212	.000
Communicate effectively	18-24	.000	.000
	25-34	.091	.000

The opportunity to Improve category did not exhibit any changes by age group for cohort 1 but there was a change for 25-34 year olds in cohort 2 where they exhibited similar opinions after the active teaching period (Table 4.29 below and Table A10.72).

Table 4.29 Normality tests both postgraduate cohorts of the importance of improvement split by age.

	Age at last birthday	Shapiro-Wilk Pre-teaching responses Sig.	Shapiro-Wilk Post teaching responses Sig.
IMPROVE_Cohort 1	18-24	.000	.000
	25-34	.004	.001
IMPROVE_Cohort 2	18-24	.000	.000
	25-34	.091	.000

Previous experience of active teaching style

Teaching style impact was only tested for postgraduate cohorts as some impact may have been evident through respondents' previous experience of active or passive teaching. Tests to check for such differences by comparing those who had claimed experience of active teaching and those who had not are combined in the following tables.

Cohort 1 show no differences in the importance of knowledge, the importance of skills or the opportunity to improve categories. Cohort 2 did show one difference in the importance of knowledge category that was statistically significant. Full tables can be seen in A10.77a to A10.81b.

Table 4.30 Hypothesis tests cohort 2 of postgraduate teaching style differences of the importance of existing knowledge.

Knowledge Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Design and Production	.024	.171	Moderately less significant

'Design and production' is the only item showing a significant change so was analysed further to try and identify a reason. The only indicator found was mean scores and looking at their respective means from pre to post may indicate why the item is now non-significant (Table 4.31).

Table 4.31 Hypothesis tests Cohort 2 of postgraduate teaching style means for the importance of existing knowledge in Design and Production.

Importance of Knowledge Category Item	Passive average Pre to Post	Active average Pre to Post	Comment
Design and Production	Pre – 3.91 Post – 4.30	Pre – 4.39 Post – 4.59	*Both Passive and Active teaching styles have a higher average but are more closely aligned after teaching despite the respondents' previous experience of teaching.*

No significant changes are indicated in the importance of skills category. However, distribution of their views on importance of improvement across teaching style for cohort 2, whilst not in the statistically significant range, is strongly less significant moving from .058 to .895.

Non-Parametric tests

As discussed earlier in Section 4.1, for repeated measures the Wilcoxon Signed Rank test is appropriate and for independent samples the Mann-Whitney U test is used. The following statistically significant results, obtained for each cohort, are set out below. Tables A10.20a to A10.20e refer.

Undergraduate Cohorts

Table 4.32 Wilcoxon Signed Rank Test for knowledge, skills, self-esteem and self-efficacy from undergraduate cohort 1 (using passive teaching)

Scale	Question	Significance	Z	n	R - effect	Effect Size	Mean Pre to Post teaching
The importance of Knowledge	Sales and marketing	.046	-2	66	.246	Medium	3.33 – 3.27
	Quality Management	.046	-2	66	.246	Medium	4.33 – 4.33
	Project Planning	.059	-1.89	66	.233	Medium	4.55 – 4.18
The importance of Skills	Creativity	.046	-2	66	.246	Medium	4.33 – 4.33
Self-esteem	Relying on Oneself	.058	-1.897	66	.233	Medium	2.48 – 3.30
Self- Efficacy and Learning style	No questions were found to have any significant effects						
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation from pre-teaching to post teaching is reported according to Cohen (1988).							

Table 4.32 shows a significant reduction in undergraduate student perceptions of the importance of having knowledge of Sales and Marketing and significant change in their perception of the importance of having knowledge of Quality Management (no direction of change is evident) but in both cases the effect is of medium size (using Cohen's 1988 criteria for effect size where 0.1 = small, 0.3 = medium and 0.5 = large). Means are reported to try and identify direction of change as median scores on a scale of 1-5 in such a small sample tend to be the same. The importance of knowledge of Project Planning is not shown as significant here (.059) but is reported to show comparison using paired sample statistics in Table 4.33 below. Similarly, the importance of being creative shows a significant change but direction is not obvious although the effect is of medium size. Self-esteem and self-efficacy tests show no significant results but student opinions of their ability to rely on themselves indicates a close to significant rise.

Given the above results and the inconclusive evidence on the distribution pattern of the data, confirmatory tests using paired sample tests and correlations (n = 8) for the same scales and items were carried out, Table 4.33 summarises the findings. Partial eta squared is used to calculate the effect size based on Cohen (1988, pp.284-287) where .01 is a small effect, .06 is medium and .14 is large. The partial eta squared effect measure explains the percentage of variation in the question that is explainable through the differing choices made by cohort 1 respondents pre to post teaching. Note there is a significant result shown using the paired samples test for ‘Project Planning’ that was not seen using the Wilcoxon Signed Rank Test. This indicates decreased support for hypothesis H1 – the possibility that active teaching has a positive impact on project planning. Whilst this does show a statistically significant reduction in the importance of knowledge in project planning, the effect is small. Given the contradictory result from different tests and the very small sample rate, the possibility that this is a rare result cannot be ruled out. Self-esteem and self-efficacy categories show no significant results, the self-esteem measure is shown for comparison to that in Table 4.32 above.

Table 4.33 Paired Sample Tests from undergraduate cohort 1 for knowledge, skills, self-esteem and self-efficacy.

Scale	**Question**	**Paired Samples Tests**					
		Mean Pre to Post teaching	***SD***	***df***	***t***	***Sig. (2-tailed)***	***Effect Value (Partial Eta squared)***
The importance of Knowledge	Sales and marketing	3.50 to 3.00	.050	7	.246	.033	<0.001 (Small)
	Quality Management	4.75 to 4.25	.078	7	.246	.033	<0.001 (Small)
	Project Planning	4.75 to 4.13	.776	7	.233	.049	<0.001 (Small)
The importance of Skills	Creativity	3.88 to 4.38	.122	7	-2.646	.033	0.500 (Large)
Self-Esteem	Relying on Oneself	2.38 to 3.38	.650	7	-2.000	.086	0.364 (Large)
Self-Efficacy and Learning style	No questions were found to have any significant effects						
Effect size (partial eta^2) is explained above and is given by: $t^2 / (t^2 + df)$.							

For cohort 2 and from Table 4.34 there appears to be a significant reduction in student perceptions of their ability to cope with stress and their ability to remember lecture content but a significant rise in their ability to keep to their plans. From a learning style perspective, we saw no major changes for cohort 1 but here we note a significant drop in willingness to try out something new through experimentation (i.e. a move towards auditory and/or visual) on practical matters, and a greater willingness to listen carefully (i.e. move towards auditory and/or visual) for more information-based aspects of their lives. Using Cohen's (1988) criteria for effect size, means are again reported to try and identify the direction of change.

Table 4.34 Wilcoxon Signed Rank Test for knowledge, skills, self-esteem and self-efficacy for undergraduate cohort 2 (using active teaching).

Scale Category	Question	Significance	Z	n	R - effect	Effect Size	Mean Pre to Post
Importance of Knowledge & Importance of Skills	No questions were found to have any significant effects in either of these two categories						
Self-Esteem	Being calm under stress	.028	-2.200	50	-.357	Medium	4.00 to 3.74
	Sticking to my plans 2	.034	-2.123	50	.338	Medium	3.05 to 3.35
Self- Efficacy	Remember Engineering Design lecture content	.003	-2.922	50	-.211	Small	4.98 to 3.37
Learning Style	When cooking a new dish	.015	-2.434	50	-.403	Medium	2.05 to 1.77
	When choosing a holiday	.001	-3.443	50	-.557	Large	2.28 to 1.81
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation pre-teaching to post teaching is reported according to Cohen (1988).							

Table 4.34 indicates mainly small to medium effect sizes with the exception of the learning style shift toward auditory (listening) where it is needed to gain the appropriate knowledge. Examining those learning style results that were not statistically significant for tendency through mean scores for cohort 2 indicates that items looking at learning new skills tend to have kept very similar scores. Items that indicate a need for new knowledge have a mix of moves towards taking instruction and moves towards experimentation. Similarly, to cohort 1 results, confirmatory tests using paired sample tests and correlations were carried out. Some additional items are now included, Table 4.35 summarises the findings. The effect measure indicates the percentage of variation in the item that is explainable through the choices made by a students' experience of teaching style. All these effects may not be attributable to the teaching approach but serve as a base line for comparison. No other items show any significant changes overall.

Table 4.35 Paired Sample Tests for knowledge, skills, self-esteem, self-efficacy and learning style for undergraduate cohort 2.

Scale Category	Question	Paired Sample Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect value (partial eta squared)
Importance of Knowledge & Skills	No questions were found to have any significant effects in either of these two categories						
Self-Esteem	Being calm under stress	4.00 to 3.74	.727	42	2.308	.026	.112 (Medium)
	Sticking to my plans 2	3.05 to 3.35	.887	42	-2.234	.031	.106 (Medium)
Self- Efficacy	Remember Engineering Design lecture content	4.98 to 3.37	7.619	42	1.381	.175	.043 (Small)
Learning Style	When cooking a new dish	2.05 to 1.77	.694	43	2.606	.013	.136 (Medium)
	When choosing a holiday	2.28 to 1.81	.735	42	4.149	.000	.290 (Large)
Effect size (partial eta^2) is explained above and is given by: t^2 / (t^2 +df).							

Looking at the final column in Table 4.35, 2-tailed t-tests support the significance results seen from the Wilcoxon signed rank tests with one exception – the item in self-efficacy which is reported for comparison purposes. Even though ‘remember engineering design lecture content’ was not statistically significant in t-tests it reflects the small effect value we saw previously in Table 4.34, supporting results for other effect values.

Postgraduate Cohorts

For postgraduate responses no items were found to have any significant effects on the importance of knowledge, the importance of skills or Improvement opportunity categories. Table 4.36 shows a significant improvement in respondents’ confidence in the 12 self-esteem items listed. Similarly, there appears to be an improvement in their confidence to do things in the future (self-efficacy) in seven items. In all cases where an effect was seen the effect is of medium size (using Cohen’s 1988 criteria for effect size). Means are reported to identify the direction of change.
The effect measure was calculated to determine the percentage of variation in the item that is explainable through the choices made by respondents in cohort 1. There is a medium effect in all categories/items shown. See also Tables A10.76a to A10.76e.

Given the results in Table 4.36 below, confirmatory tests using paired sample tests and correlations (n = 27) for the same scales and items were carried out. The results identified the same items in each of the categories and Eta squared is used to calculate the effect size based on Cohen (1988, pp.284-287).

Table 4.36 Wilcoxon Signed Rank Test postgraduate categories for cohort 1

Category	Question	Sig.	Z	n	R - effect	Effect Size	Mean pre to post
Self-esteem	Getting resources	.012	-2.500	66	-.307	Medium	3.56 to 3.93
	Achieving aims/goals	.016	-2.399	66	-.295	Medium	3.48 to 3.89
	Deal with unexpected events	.010	-2.560	66	-.315	Medium	3.41 to 4.00
	Resourcefulness	.007	-2.696	66	-.332	Medium	3.48 to 3.96
	Relying on oneself	.036	-2.101	66	-.259	Medium	3.07 to 3.56
	Investing the appropriate effort	.007	-2.696	66	-.332	Medium	3.81 to 4.33
	Sticking to my plans	.002	-3.312	66	-.407	Medium	2.74 to 3.48
	Being calm under stress	.034	-2.125	66	-.262	Medium	3.44 to 3.89
	Coping with uncertainty	.001	-3.231	66	-.398	Medium	3.56 to 4.19
	Acceptance of challenges	.011	-2.556	66	-.315	Medium	3.26 to 3.70
	Making sensible	.040	-2.056	66	-.253	Medium	3.52 to 3.96
	Sticking to my plans 2	.041	-2.045	66	-.252	Medium	3.59 to 3.96
Self-Efficacy	Take useful class notes	.010	-2.563	66	-.315	Medium	3.67 to 4.04
	Use the library and search engines	.041	-2.041	66	-.251	Medium	3.48 to 3.85
	Remember 'Eng. Design' lecture	.035	-2.106	66	-.259	Medium	3.37 to 3.85
	Remember 'Eng. Design' practical	.007	-2.711	66	-.333	Medium	3.48 to 3.96
	Design & construct an experiment	.031	-2.162	66	-.266	Medium	3.26 to 4.00
	Lead a technical team	.005	-2.820	66	-.347	Medium	3.37 to 4.19
	Document technical procedures	.001	-3.307	66	-.407	Medium	3.67 to 4.04
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation (effect size) from pre-teaching to post teaching is reported according to Cohen (1988).							

Using paired sample tests, student perceptions of the importance of knowledge, skill or improvement are not shown to be significant which agrees with the previous Wilcoxon Signed Rank test. The penultimate column in Table 4.37 below shows a significant improvement in respondent's confidence in all of the self-esteem items listed and the same seven self-efficacy items as previously tested.

Table 4.37 Paired Sample Tests postgraduate categories for cohort 1

Category	Question	Paired Samples Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect Value (Eta squared)
Self-esteem	Getting resources	3.56 to 3.93	.688	26	-2.798	.010	.231 (Large)
	Achieving aims/goals	3.48 to 3.89	.797	26	-2.656	.013	.214 (Large)
	Deal with the unexpected	3.41 to 4.00	1.083	26	-2.842	.009	.237 (Large)
	Resourcefulness	3.48 to 3.96	.802	26	-3.118	.004	.272 (Large)
	Relying on Oneself	3.07 to 3.56	1.087	26	-2.301	.030	.169 (Large)
	Investing the appropriate effort	3.81 to 4.33	.935	26	-2.881	.008	.242 (Large)
	Stick to my plans	2.74 to 3.48	.984	26	-3.911	.001	.370 (Large)
	Being calm under stress	3.44 to 3.89	.974	26	-2.371	.025	.223 (Large)
	Coping with uncertainty	3.56 to 4.19	.839	26	-3.900	.001	.369 (Large)
	Acceptance of challenges	3.26 to 3.70	.801	26	-2.884	.008	.257 (Large)
	Making sensible judgments	3.52 to 3.96	1.050	26	-2.199	.037	.157 (Large)
	Stick to my plans 2	3.59 to 3.96	.884	26	-2.178	.039	.154 (Large)
Self-Efficacy	Take useful class notes	3.33 to 3.89	1.013	26	-2.850	.008	.253 (Large)
	Use the library and search engines	3.67 to 4.04	.884	26	-2.178	.039	.154 (Large)
	Remember 'Eng. Design' lecture	3.48 to 3.85	.839	26	-2.294	.030	.168 (Large)
	Remember 'Eng. Design' practical	3.37 to 3.85	.802	26	-3.118	.004	.272 (Large)
	Design & construct an experiment	3.48 to 3.96	1.051	26	-2.380	.025	.179 (Large)
	Lead a technical team	3.26 to 4.00	1.130	26	-3.407	.002	.308 (Large)
	Document tech' procedures	3.37 to 4.19	1.001	26	-4.228	.000	.407 (Large)
Effect value (eta^2) is given by $t^2/(t^2 + df)$.							

For cohort 2, there were only a few items in all categories that resulted in a significant output (i.e. below 0.05) indicating that there is an actual difference between the two groups of results. Table 4.38 picks out the three items that qualify.

Table 4.38 Wilcoxon Signed Rank Test significant differences (postgraduate categories for cohort 2).

Category	Question	Sig.	Z	n	R - effect	Effect Size	Mean Pre to Post
Importance of knowledge	Design and production	.011	-2.547	47	.392	Medium	4.09 to 4.43
Self-esteem	Generating solutions to problems	.036	-2.100	47	.328	Medium	3.55 to 3.81
Self-efficacy	Take useful class notes	.001	-3.197	47	-.573	Large	4.40 to 3.91
No items were found to have any significant effects in the following categories 1) Importance of skills, 2) Improvement opportunity and 3) Learning Style. Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation (effect size) from pre-teaching to post teaching is reported according to Cohen (1988).							

From Table 4.38 there appear to be some interesting issues:

a. The importance of knowledge in 'design and production' for engineers was shown to have good reliability pre-teaching with inter-item correlation average at .479 but poor reliability post teaching with inter-item correlation average very low at .152. A similar reliability profile is seen for the self-esteem item 'generating solutions to problems' where the average inter-item correlation value dropped from .309 pre-teaching to .210 post teaching.
b. Conversely there appears to be a significant reduction in the perceived collective ability to do things in the future (self-efficacy) for the item 'taking class notes' – this effect is large and thus indicates a strong relationship. The reliability profile for the self-efficacy item 'take useful class notes' shows an overall rise where the average inter-item correlation value changed from .207 pre-teaching to .315 post teaching.

Confirmatory tests using paired sample tests and correlations (n = 47) for the same scales and items were carried out. The results identified the same items in each of the categories and Eta squared is used to calculate the effect size based on Cohen (1988, pp.284-287).

Table 4.39 Paired Sample Tests for importance of knowledge, self-esteem and self-efficacy for postgraduate cohort 2.

Scale	Question	Paired Samples Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect Value (Eta squared)
Knowledge	Design and production	4.09 to 4.43	.867	46	-2.693	.010	.136 (Medium)
Self-Esteem	Generating solutions to problems	3.55 to 3.81	.793	46	-2.207	.032	.096 (Medium)
Self-Efficacy	Take useful class notes	4.40 to 3.91	.855	46	3.609	.001	.221 (Large)
	Write a clear and precise project plan	3.87 to 4.15	.722	46	-1.952	.057	.076 (Medium)

No items were found to have any significant effects in the following categories 1) The importance of Skills, 2) Learning Styles and 3) Improvement opportunity.

Eta^2 – effect value is given by: $t^2/(t^2 + df)$. Effect size for the paired samples test is discussed

Looking at the final column in Table 4.39, student perceptions of the importance of knowledge for ‘design and production’ show a medium sized rise and their self-esteem regarding ‘generating solutions to problems’ also shows a medium sized increase. However, the impact on the self-efficacy item for ‘take useful class notes’ shows a large decrease indicating the cohort as a whole has less confidence in their ability to do this as they progress on their course. This could also reflect the fact that they have experienced lots of active lectures, notes are given up-front for them to read and discuss thus lessening their willingness to capture key points during the lecture. A near miss for significance is included in the self-efficacy scale for ‘writing clear and precise project plans’ because project management was the module through which the post-graduate students were studied. It indicates a medium sized rise in their confidence levels going forward even though not a statistically significant result. No items in the skills, improvement or learning style categories are shown to be significant – this agrees with the previous Wilcoxon Signed Rank test.

4.3.2 Tests for Hypothesis 2 – Learning style impact.

H2 – A learner's preferred learning style can be affected by being exposed to an active teaching approach.

Descriptive Statistics.

Learning style questions based on the VAK model (Dunn, 1990) were considered (see Tables A10.10a and A10.10b) and the scales used were; Visual = 1, Auditory = 2 and Kinaesthetic = 3. The mean score shown therefore indicates a cohort tendency rather than an individual tendency towards one of three main styles of learning. The only changes that may indicate a change of preference for undergraduate cohort 1 are item 3 (cooking a new dish) moving strongly from visual to auditory and item 8 (shopping for new clothes) where a clear shift towards kinaesthetic preference is evident. This is probably noise in the data due to situational effects outside the control of the researcher as no other shifts in preference are evident for cohort 1 either in mean scores or visual inspection of responses per category. However, for undergraduate cohort 2 only item 7 (choosing a holiday) showed any potential change, moving slightly towards the visual style of learning preference. These minor changes are surprising and imply that passive teaching may encourage a slightly more kinaesthetic learning style but that active teaching has had little effect on these undergraduate cohorts in the way that they prefer to learn.

For postgraduate cohorts (Tables A10.53a, A10.53b, A10.59a and A10.59b), there are no major changes that may indicate a change of learning style preference through distribution of data for either cohort 1 or cohort 2, which was a surprise as it was thought that active teaching might alter a student's learning preference.

Gender Differences – Undergraduate Cohorts

As there may be an effect on descriptive statistics for learning style through responses made by different genders, checks were carried out for impact of gender choices on learning style questions.

Table A10.15a shows three changes for undergraduate cohort 1, all were for female respondents. The items 'if I were teaching someone something new…' and 'in general conversation I would tend to say…' moved to a normally distributed values (Sig values for both items pre-teaching = .000 to post teaching values = .086) and the item 'when I concentrate…' moved to a non-normally distributed value (Sig value pre-teaching = .056 to post teaching = .000).

For undergraduate cohort 2 there are five changes identified, again all for female respondents, summarised in Table 4.40 (see also A10.15b).

Table 4.40 Normality tests by gender for learning style changes undergraduate cohort 2

Tests of Normality							
		Shapiro-Wilk Pre-teaching			Shapiro-Wilk Post teaching		
	Gender	Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	Female	.782	8	.018	.818	7	.062
If I am teaching someone something new I tend to	Female	.827	8	.056	.664	7	.001
If I were choosing a holiday I would prefer to	Female	.641	8	.000	.818	7	.062
When I concentrate, I most often	Female	.835	8	.067	.769	7	.020
When I am learning a new skill, I feel most comfortable when	Female	.827	8	.056	.664	7	.001

It is evident that active teaching has affected undergraduate females more than passive teaching in terms of learning style changes when looking at distribution of data. However, one must be careful to draw too many conclusions as the total number of female responses is small compared to male responses and may have skewed the result slightly. Alternatively, female respondents during active teaching may be more willing to question their own preferred methods for learning when presented with a different approach. The result may be tempered slightly as for cohort 2, 50% of female respondents claimed previous experience of active teaching thus tests to verify the above were carried out.

Mann-Whitney U tests (Table A10.21a) identified a significant difference (value .004 and .041) in distribution between genders for two learning style items in cohort 1 but none for cohort 2 (Table A10.21b). Cohort 2 results for the items that changed in cohort 1 are reported for comparison in Table 4.41.

Table 4.41 Hypothesis tests of undergraduate gender differences in preferred learning style.

Learning Style Category Item	**Mann-Whitney U Cohort 1**		**Mann-Whitney U Cohort 2**	
	Pre-teaching	Post teaching	Pre-teaching	Post teaching
If I am teaching someone something new I tend to..	.004	.531	.473	.944
If I were out shopping for clothes I would tend to…	.041	.288	.985	.475

The results shown in Table 4.41 contradict the tests for distribution of data for cohort 2 in that there is no evidence of active teaching affecting males or females differently.

Gender Differences – Postgraduate Cohorts

For postgraduate cohorts, checks were carried out for impact of gender choices on learning style questions but when testing for distribution using Shapiro-Wilk tests (see Tables A10.64a and A10.64b) none were evident. Testing for gender differences through median scores using Mann-Whitney U tests revealed some tendencies but no significant differences for cohort 1 (Table A10.69a). However, there were some significant differences shown for cohort 2 (Table A10.69b) that are highlighted in Table 4.42 and might indicate that there is a different effect on preferences for learning for males versus females from use of an active teaching approach.

Table 4.42 Hypothesis tests of postgraduate gender differences in preferred learning style.

Learning Style Category Item	**Mann-Whitney U Cohort 1**		**Mann-Whitney U Cohort 2**	
	Pre-teaching	Post teaching	Pre-teaching	Post teaching
If I am cooking a new dish I generally...	.849	.194	.003	.250
In general conversation I would tend to say…	.306	.940	.021	.798
During my free time I would rather…	.180	.900	.010	.015

No other items show any significant changes overall between genders.

Age Related Differences

Tests of normality for learning preference against age for postgraduate groups only for cohort 1 indicated five differences, all in the 25-34 year old bracket (Table 4.43 compares both phases). One item moved to the non-significant range where four items moved into significance after the teaching experience. However, for cohort 2 again there were no differences in the 18-24 age bracket and an overall shift towards a more kinaesthetic learning style for the 25-34 age bracket. Two items ('teaching something new' and 'choosing a holiday') moved from significant to non-significant whilst two other items ('general conversation' and 'concentration') moved from non-significant to significant. See Tables A10.75a and A10.75b for full results).

Table 4.43 Postgraduate responses of their learning preference (VAK) split by data collection.

Category Item	Age at last birthday	Shapiro-Wilk Cohort 1		Shapiro-Wilk Cohort 2	
		Pre	Post	Pre	Post
If I am cooking a new dish I	25-34	.000	.314	Non-normal Distribution	
If I am teaching someone	25-34	.325	.006	.055	.000
In general conversation I	25-34	.325	.000	.012	.055
During my free time I would	25-34	.314	.006	Non-normal Distribution	
If I were choosing a holiday	25-34	.325	.006	.055	.049
When I concentrate, I most	25-34	Non-normal Distribution		.012	.055

Non-Parametric tests

Data on respondents' previous experience of Passive/Active teaching was not collected for undergraduate cohort 1 so cannot be reported upon – this error was corrected for when collecting data for cohort 2 but there are no statistically significant results in any category (see Tables A10.22 to A10.26).

For postgraduate cohorts, comparing tests within each cohort for learning style preference changes we see no overall effect for either cohort. However, there are certain category items that do show a significant change as captured in Table 4.44.

Table 4.44 Wilcoxon Signed Rank Test postgraduate categories for cohort 1

Category	Question	Sig.	Z	n	R - effect	Effect Size	Mean Pre to Post
Learning style	When I operate new equipment	.013	-2.496	66	-.307	Medium	1.73 to 1.38
	In general conversation I would tend to say	.039	-2.066	66	-.254	Medium	2.04 to 1.70
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation (effect size) from pre-teaching to post teaching is reported according to Cohen (1988).							

The results shown indicate a move towards a more visual learning style preference in these items for postgraduate cohort 1. Paired sample tests were carried out to confirm the above results and are shown in Table 4.45.

Table 4.45 Paired Sample Tests postgraduate categories for cohort 1

Category	Question	Paired Samples Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect Value (Eta squared)
Learning style	When I operate new equipment	1.73 to 1.38	.629	25	2.807	.010	.232 (Large)
	In General conversation I would tend to say	2.04 to 1.70	.784	26	2.208	.036	.158 (Large)
Effect value (eta^2) is given by $t^2/(t^2 + df)$.							

Using paired sample tests of student perceptions of their preference for learning style, the same two items again for cohort 1 indicate a move towards a more visual style of learning would be preferred. The two tests only differ in their evaluation of the strength of this significant move. For postgraduate cohort 2, the same tests were completed but no significant changes were identified (Table A10.76e has all details).

Experience of active teaching style

There are some changes in both undergraduate and postgraduate cohorts indicating that previous teaching style experience may have led to different responses. Tests to check for such differences for effect on learning style showed no differences for either undergraduate or postgraduate cohort 1 but the item 'in general conversation' moved to a statistically significant difference for postgraduate cohort 2 (Tables A10.81a and A10.81b). There is an indication this difference may be age related (see previous findings Table 4.43) as these results are opposite for cohort 1 compared to cohort 2. This might be cohort specific but it could indicate that active teaching affects student confidence levels positively for the item.

Summarising the findings from this section we have seen that passive teaching might encourage a slightly more kinaesthetic learning style and that the changes were found only in female respondents, males showed no changes at all. Overall changes in preference for learning style in all cohorts seem minimal but the only evident significant changes are those from the older age range and that male/female responses for postgraduate cohort 2 were affected more. An indication only that active teaching may have more impact than passive teaching on choices made by gender.

4.3.3 Tests for Hypothesis 3 – Thinking style impact.

H3 – A learner's preferred thinking style can be affected by being exposed to an active teaching approach.

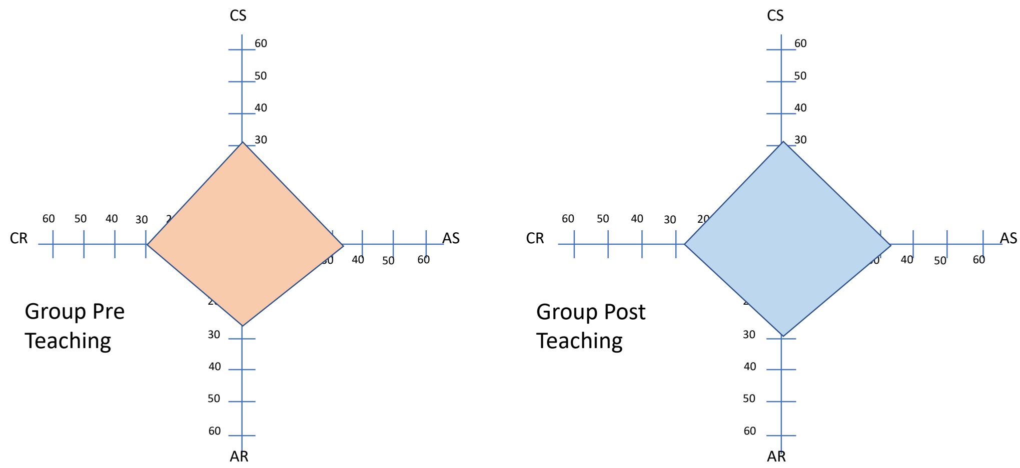
Thinking style data was collected using the model produced by Gregorc (1984) and the categories produced are defined as follows (see Section 3.4):

> **Concrete Sequential** (CS) thinkers tend to be based in reality. They process information in an ordered, sequential, linear way.
>
> **Abstract Sequential** (AS) thinkers love the world of theory and abstract thought.
>
> **Abstract Random** (AR) thinkers organise information through reflection and thrive in unstructured, people-oriented environments.
>
> **Concrete Random** (CR) thinkers are experimenters.

Undergraduate Cohorts

When analysing the thinking style data between groups and individuals for undergraduate cohort 1 (Pre to Post teaching) Figure 4.1 shows that as a group there is only a small shift, not significant, towards a more reflective approach.

Fig 4.1 Thinking style overall group data undergraduate cohort 1



No major differences are evident from a group perspective using averaged scores - only minor drops in CS & AS, a slightly larger drop in CR (29.70 becomes 28.00) but a small rise in AR (25.70 becomes 28.50) moving away from experimental thinking to a more reflective style, being more comfortable with people-oriented environments overall.

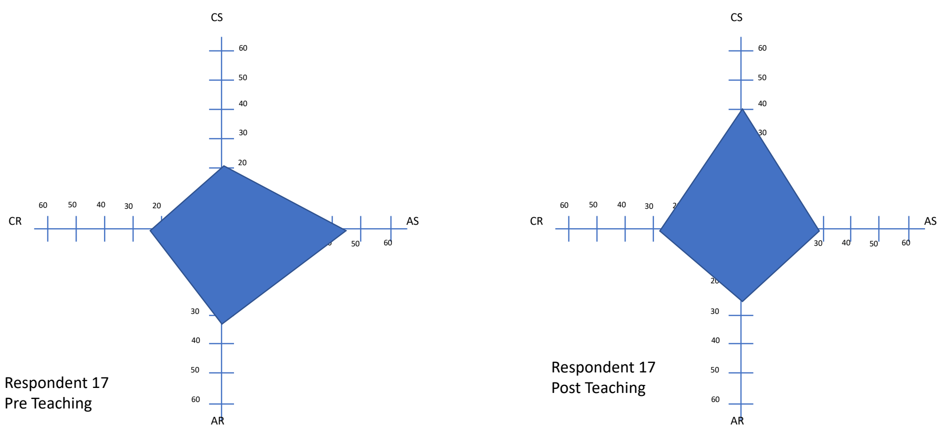
When looking at individual cases there are some more interesting effects evident. Table 4.46 picks out the eight cases from the same undergraduate respondents at both data collections. From these eight, two are reproduced below using the same chart format as for the group pre to post teaching comparison.

Table 4.46 Undergraduate responses for thinking style cohort 1

Individual undergraduate responses tracked pre to post teaching								
Respondent number	**Pre-teaching**				**Post teaching**			
	CS	AS	AR	CR	CS	AS	AR	CR
10	9	9	5	7	6	10	7	7
11	5	8	9	8	8	9	8	5
15	11	8	6	5	10	9	3	8
17	5	11	8	6	10	7	6	7
19	9	9	8	4	9	11	6	4
20	6	12	4	8	8	8	4	10
22	5	12	6	7	4	12	8	6
29	5	2	11	12	4	3	13	10

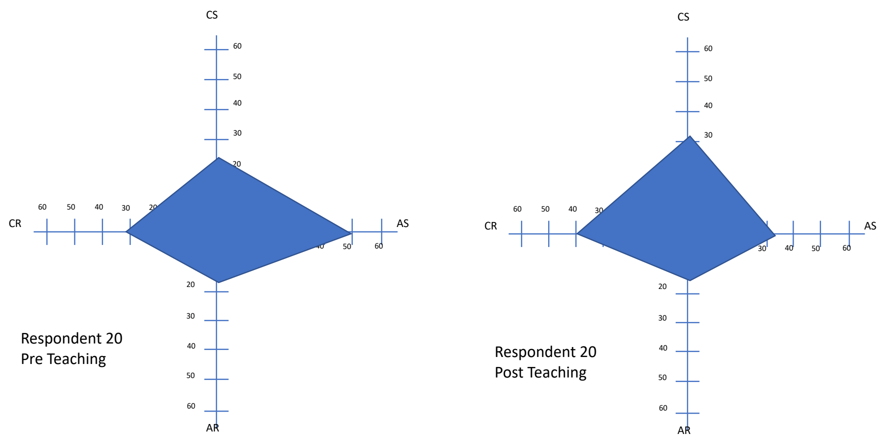
It is useful to see that there are some changes evident in specific individuals.

Fig 4.2 Thinking style respondent 17 undergraduate cohort 1



Respondent 17 indicates a preference shift away from abstract to more reality in their thinking and information processing.

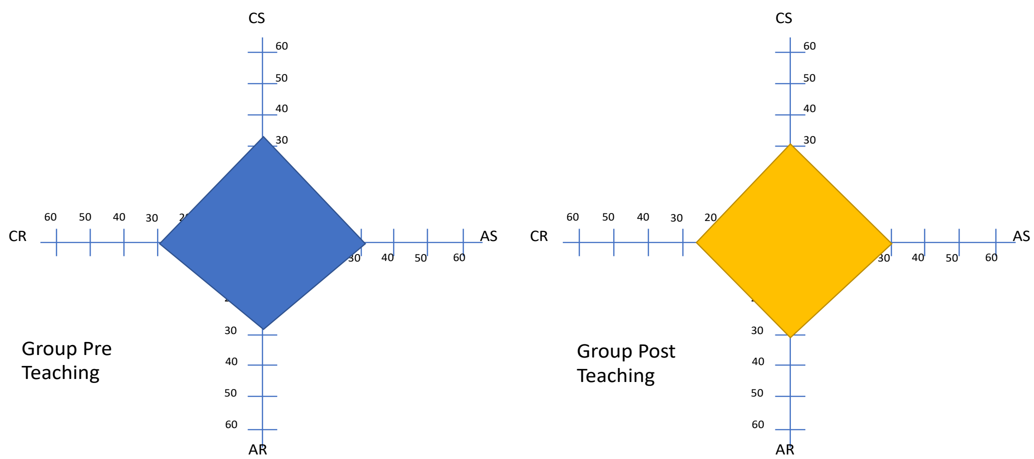
Fig 4.3 Thinking style respondent 20 undergraduate cohort 1



Respondent 20: Indicates a similar shift away from abstract but in a less marked way representing a slightly more realistic stance.

Figure 4.4 summarises the thinking style data for cohort 2 indicating that as a group there is only a small shift away from CS (31.84 becomes 29.40) and towards CR (29.75 becomes 32.48). No major differences therefore from a group perspective using averaged scores - only minor changes in AS & AR. This indicates a move away from ordered, sequential thinking to more experimentation.

Fig 4.4 Thinking style overall group data undergraduate cohort 2

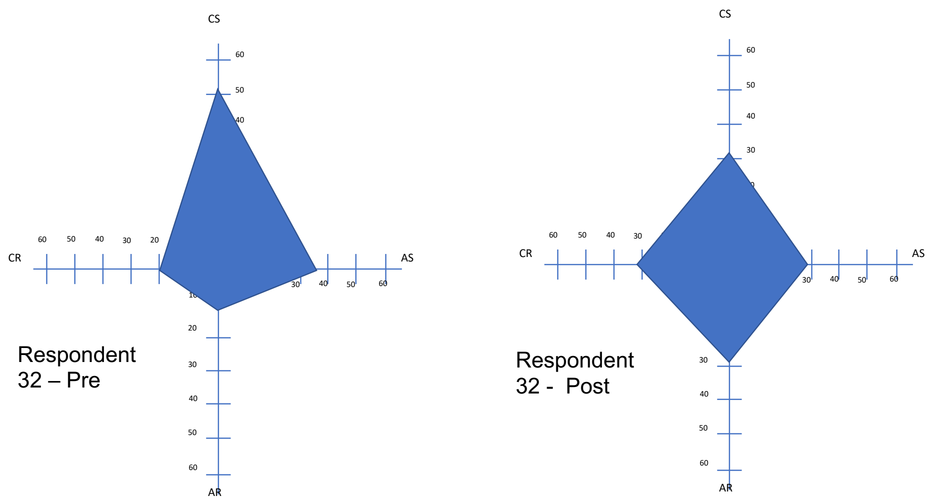


Whilst not all respondents at both data collections were selected, Table 4.47 gives the base data for two individuals who responded in both data collections and it is useful to see that there are some significant changes evident in specific individuals.

Table 4.47 Undergraduate responses for thinking style undergraduate cohort 2

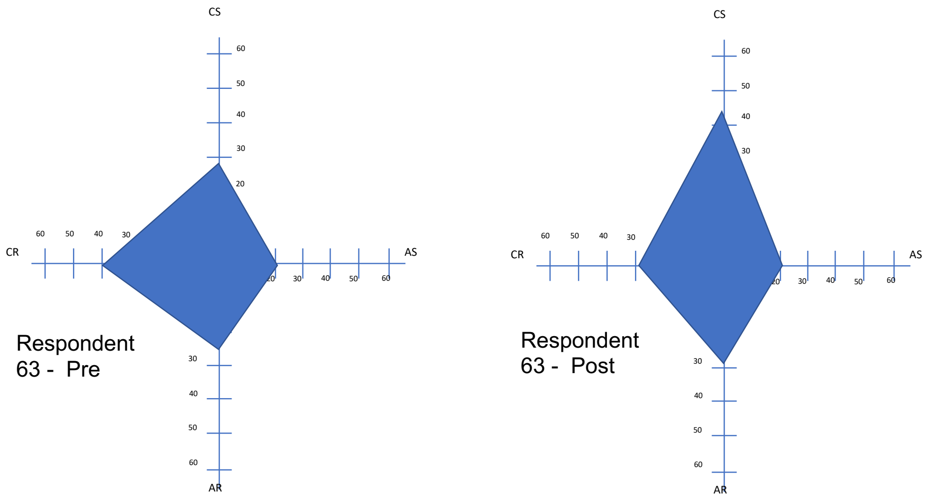
Individual undergraduate responses tracked from pre to post teaching								
Respondent number	**Pre-teaching**				**Post teaching**			
	CS	AS	AR	CR	CS	AS	AR	CR
32	13	9	3	5	8	7	7	8
63	7	5	6	10	11	5	7	7

Fig 4.5 Thinking style respondent 32 undergraduate cohort 2



Respondent 32: Indicates that abstract thinking stays the same but shows a preference shift away from sequential thinking to more experimentation and reflection in their thinking and information processing.

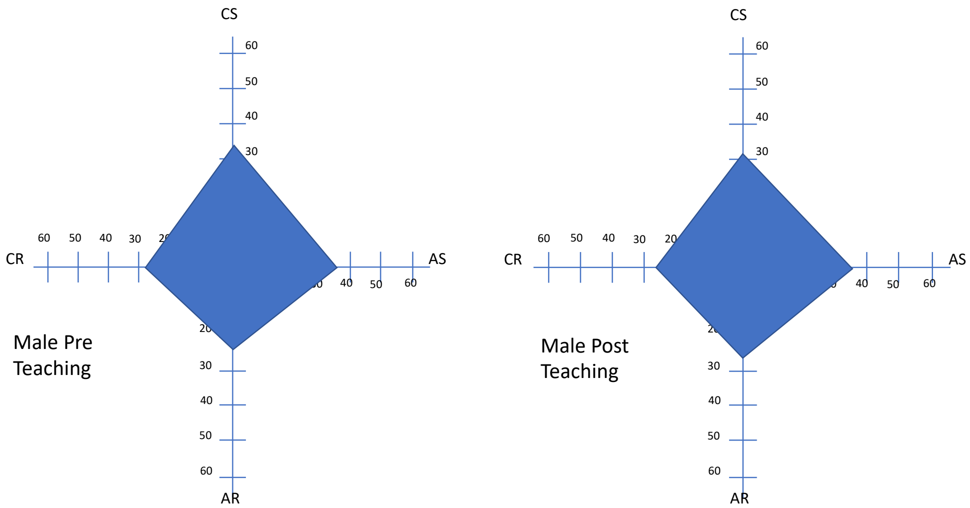
Fig 4.6 Thinking style respondent 63 undergraduate cohort 2



Respondent 63: Indicates a similar preference for abstract but an opposite move toward sequential reflective thinking, away from experimentation.

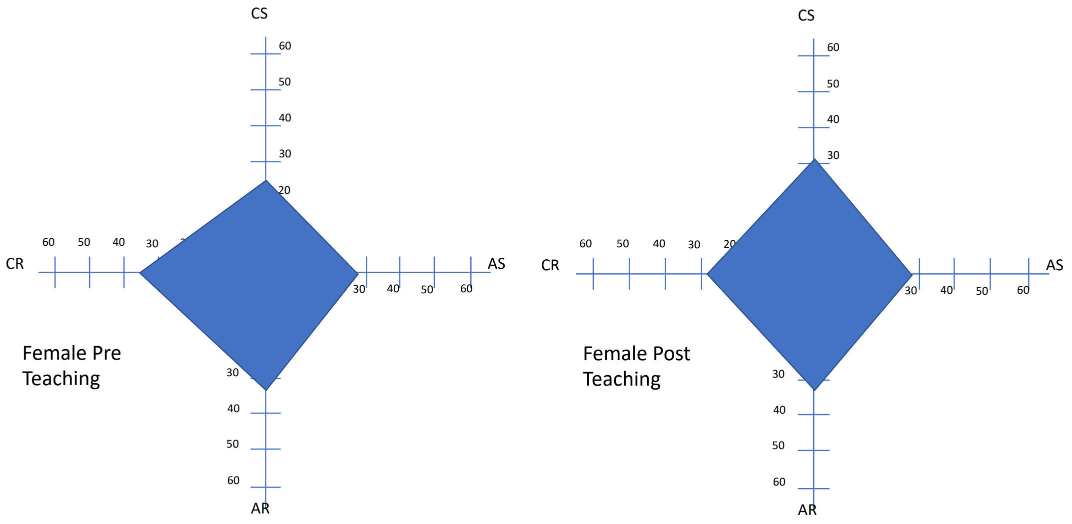
Undergraduate cohort 1 gender differences are presented in Figures 4.7 and 4.8 below.

Fig 4.7 Thinking style data by Gender Cohort 1 - Male



No major differences from a male perspective using averaged scores - only minor drops in CR & AS, a larger drop in CS and a small rise in AR moving from theory and abstract thinking to more reflective, people-oriented thinking overall.

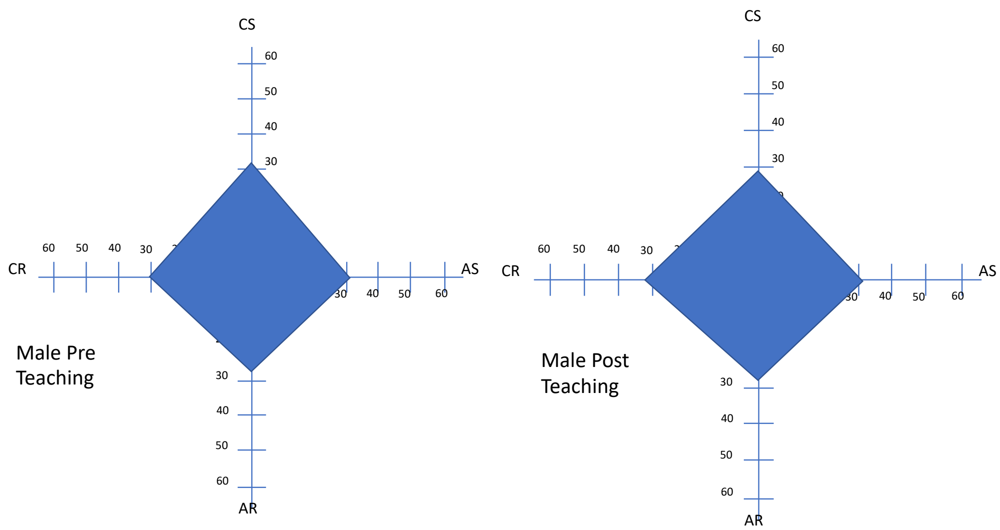
Fig 4.8 Thinking style data by Gender Cohort 1 - Female



Differences from a female perspective using averaged scores show minor drops in AS and AR, a larger drop in CR, but a large rise in CS moving towards ordered sequential thinking based on a more realistic viewpoint and quite strongly away from experimentation, reflection and unstructured thinking.

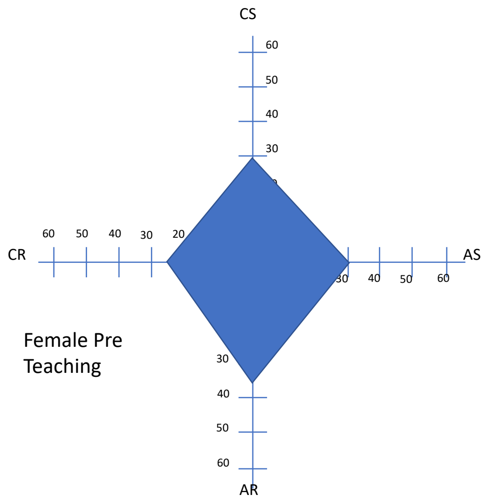
Looking at the same gender groups for cohort 2, Figures 4.9 and 4.10 below set out the male and female perspectives.

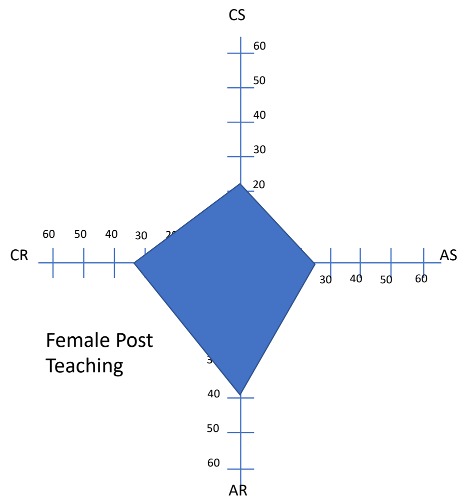
Fig 4.9 Thinking style data by Gender Cohort 2 - Male



No major differences from a male perspective using averaged scores - only a minor drop in CS and small rises in AR and CR moving from sequential ordered thinking to more reflective, people-oriented thinking overall with a hint of additional willingness to experiment. Theoretical thinking remains the same.

Fig 4.10 Thinking style data by Gender Cohort 2 - Female



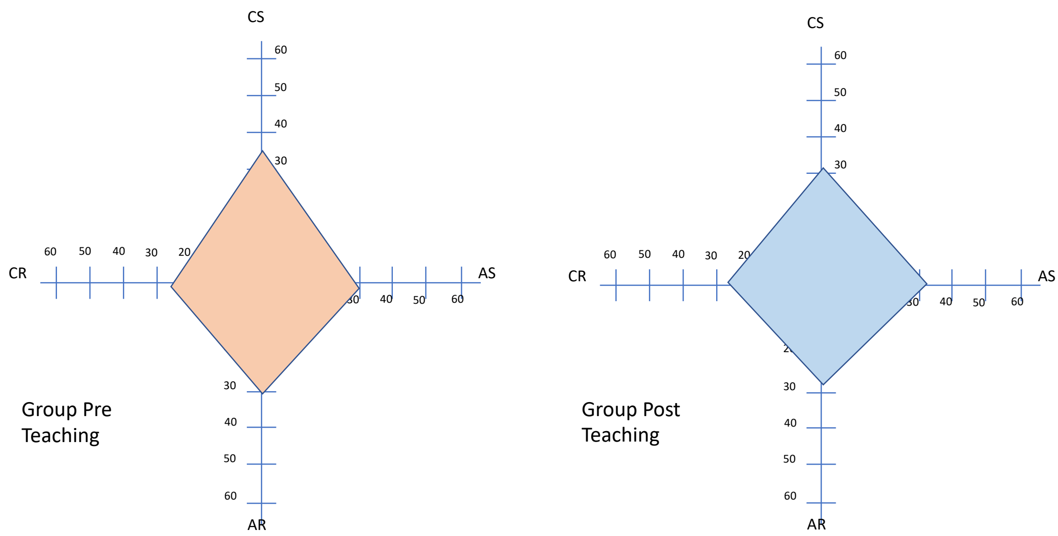


Differences from a female perspective for cohort 2, using averaged scores, show large drops in CS and AS with consequent rises in AR and CR moving strongly away from sequential and theoretical thinking towards experimental, reflective and unstructured thinking. This is different from female responses for cohort 1.

Postgraduate Cohorts

Postgraduate analyses for cohort 1 produced the following graphs showing that as a group there is only a small shift, not significant, away from a reflective approach. No major reasons can be identified from the quantitative data.

Fig 4.11 Thinking style overall group data for postgraduate cohort 1



No major differences from a group perspective using averaged scores, a drop in AR and a small rise in AS a slightly smaller rise in CR moving toward theory, abstract thinking and experimentation and away from more reflective, people-oriented environments. When looked at from an individual perspective the data shows some larger changes. Of the 23 repeat respondents, one was discarded through lack of complete data for this thinking style element, 11 showed an almost identical pattern both pre and post teaching indicating a broadly similar thinking style that has not been affected through the use of a passive teaching style. 11 respondents however did indicate some interesting changes from pre to post teaching – these are shown in Table 4.48.

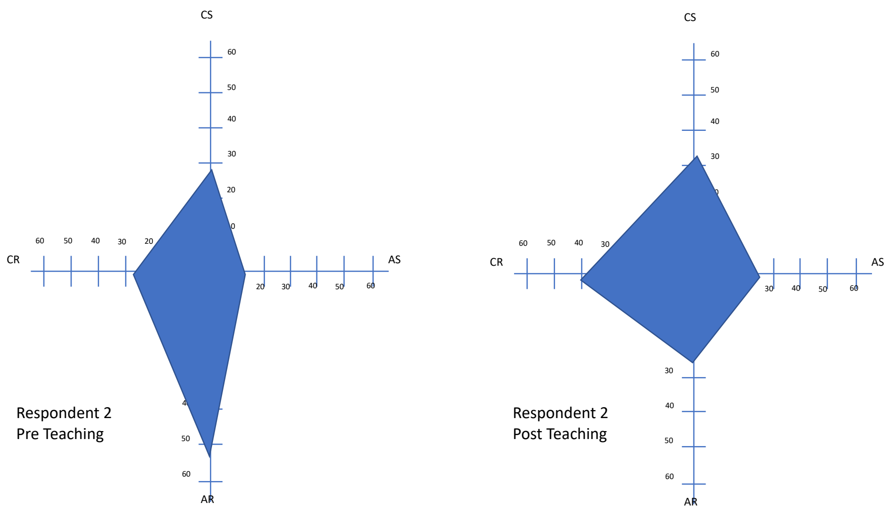
Whilst the overall postgraduate group thinking may have moved slightly away from reflective thinking for cohort 1, many of the individuals outlined in Table 4.48 seem to show a more focused drop in reflection compared to overall. There are no conclusions to be drawn because this postgraduate group are predominantly international students. Cultural differences could be at work here but some of the individual responses merit further investigation and comparison to undergraduate results during the same period where the use of a traditional, didactic teaching style has been employed.

Table 4.48 Thinking style individual data for postgraduate cohort 1

Individual UG responses tracked from Pre to Post Teaching								
Respondent	Pre Teaching				Post Teaching			
	CS	AS	AR	CR	CS	AS	AR	CR
1	11	10	3	6	7	13	3	7
2	7	3	13	7	8	6	6	10
11	6	9	6	9	9	9	3	9
12	7	7	10	6	9	9	5	7
13	6	7	6	11	6	7	9	8
15	10	4	12	4	4	12	6	8
20	13	6	5	6	10	4	7	9
21	8	10	5	7	10	6	7	7
27	5	8	11	6	9	8	6	7
28	6	11	10	3	7	8	7	8
33	9	6	8	7	8	13	4	5

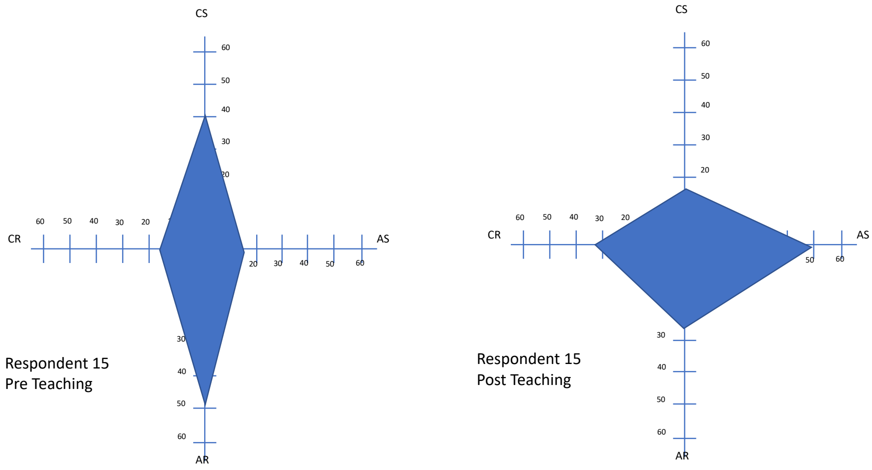
Scores are multiplied by 4 to provide meaningful comparison and graphical output in the following figures.

Fig 4.12 Thinking style individual data respondent 2 – postgraduate cohort 1



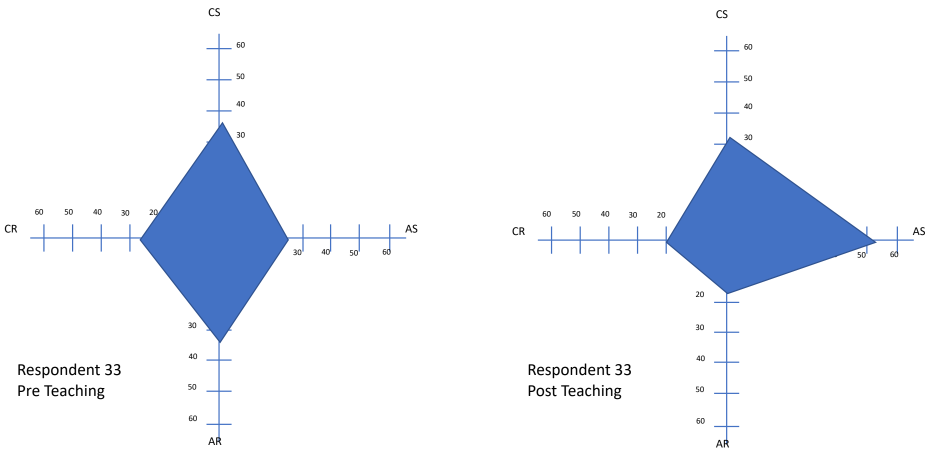
Respondent 2: Indicates a preference shift away from reflective to abstract and more experimentation in their thinking.

Fig 4.13 Thinking style individual data respondent 15 – postgraduate cohort 1



Respondent 15: Indicates significant shifts away from linear and reflective thinking to abstract, experimental thinking but this is likely to be isolated given the group average.

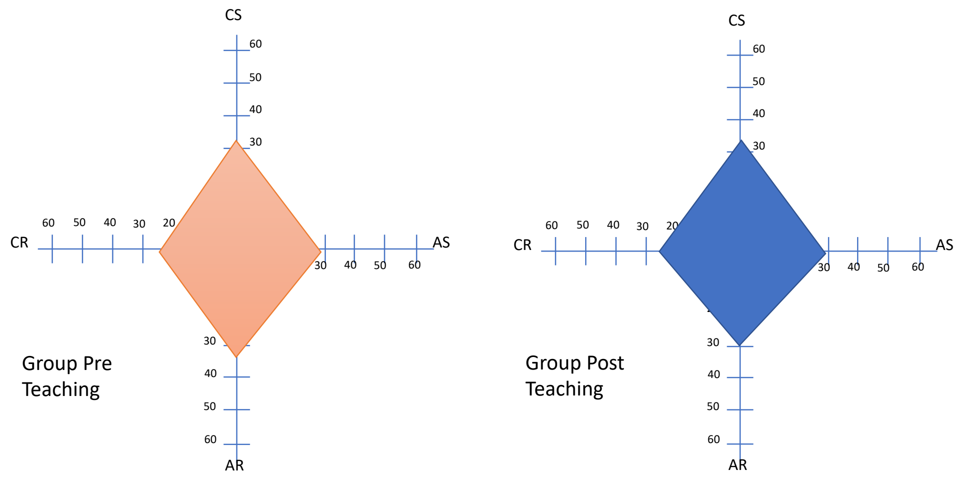
Fig 4.14 Thinking style individual data respondent 33 – postgraduate cohort 1



Respondent 33: A significant rise in abstract theoretical thinking and a move away from reflection.

When analysing the thinking style data between groups and individuals for cohort 2 the following graphs show that as a group there is only a small shift, not significant, away from a reflective approach – similar to cohort 1.

Fig 4.15 Thinking style overall group data for postgraduate cohort 2.



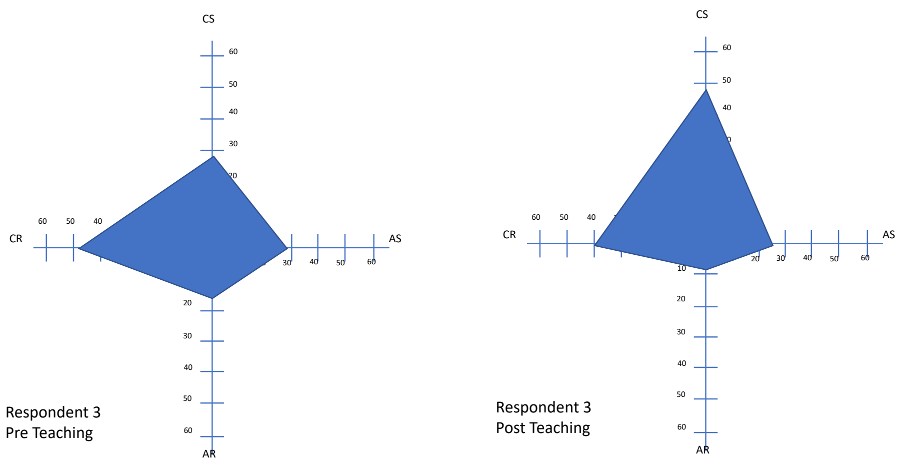
No major differences from a group perspective using averaged scores but there is a clear drop in AR tending away from reflective thinking or people-oriented environments. There are also small rises in AS and CS with a slightly smaller rise in CR moving more towards theory and abstract thinking from a practical standpoint. Some tendency towards experimentation – a small effect as a group. When looked at from an individual perspective the data shows some larger changes. Of the 53 repeat respondents, seven were discarded through lack of complete data for this thinking style element, 35 showed an almost identical pattern pre and post teaching indicating a broadly similar thinking style that has not been affected through the use of an active teaching style. 11 respondents however did indicate some interesting changes for cohort 2 – these are shown in Table 4.49.

Table 4.49 Thinking style individual data for postgraduate cohort 2

Individual PG responses tracked from pre to post teaching								
Respondent	Pre Teaching				Post Teaching			
	CS	AS	AR	CR	CS	AS	AR	CR
3	7	7	4	12	12	6	2	10
8	6	10	11	3	11	7	7	5
21	12	9	7	2	7	12	11	0
23	4	9	12	5	4	12	6	8
27	7	9	8	6	11	4	10	5
31	7	6	11	6	4	9	8	9
35	4	4	10	12	9	6	5	10
38	7	7	10	6	13	5	10	2
40	11	9	7	3	7	7	9	7
46	5	10	9	6	11	6	5	8
49	8	7	9	6	9	10	3	8

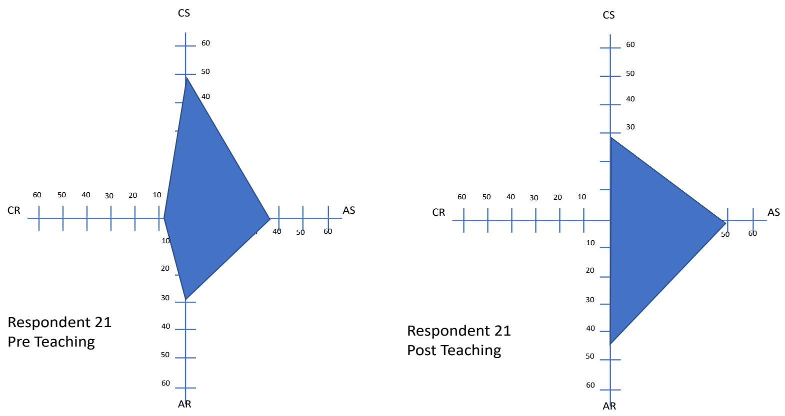
Scores are multiplied by 4 to provide meaningful comparison.

Fig 4.16 Thinking style individual data respondent 3 – postgraduate cohort 2



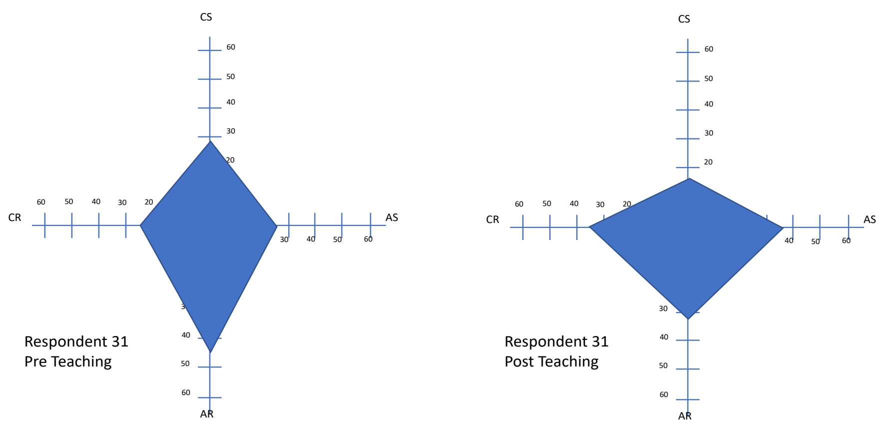
Respondent 3: Indicates significant shifts towards sequential or linear and away from reflective and experimental thinking. Of the 11 respondents featured in the table above, 6 of them show a similar tendency.

Fig 4.17 Thinking style individual data respondent 21 – postgraduate cohort 2



Respondent 21: Indicates a preference shift towards even more abstract, theoretical and reflective thinking rather than linear and definitely not experimentation. This appears to be an isolated case.

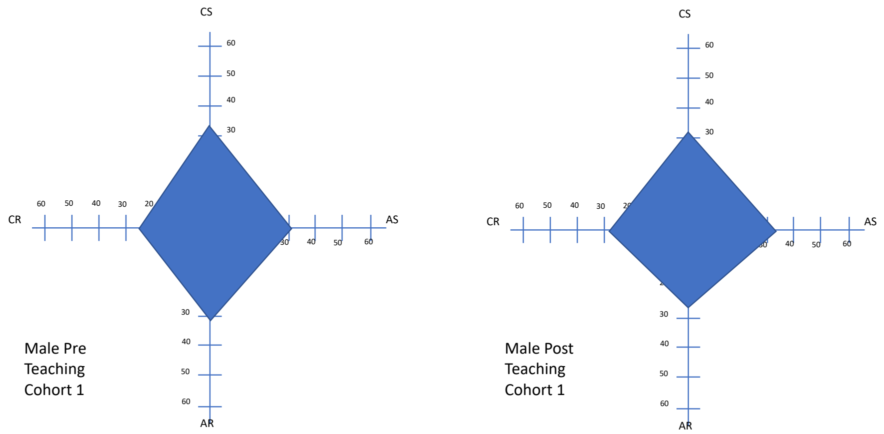
Fig 4.18 Thinking style individual data respondent 31 – postgraduate cohort 2



Respondent 31: A move away from linear/sequential thinking and reflection in favour of more abstract theoretical thinking and more experimentation. Similar patterns show in a further two of the featured cases.

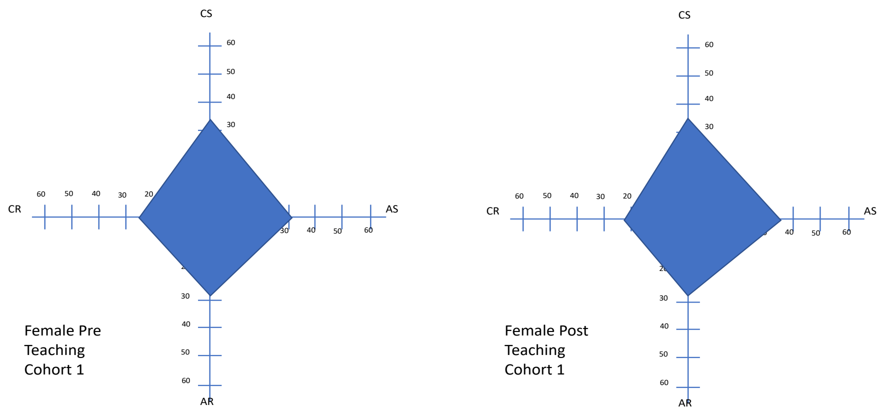
Postgraduate cohort 1 grouped gender differences are presented in Figures 4.19 and 4.20.

Fig 4.19 Thinking style data by Gender postgraduate cohort 1 - Male



No major differences from a male perspective using averaged scores - only minor drops in CS & AS, a larger drop in AR and a small rise in CR moving from reflection, theory and orderly thinking to more experimental thinking overall.

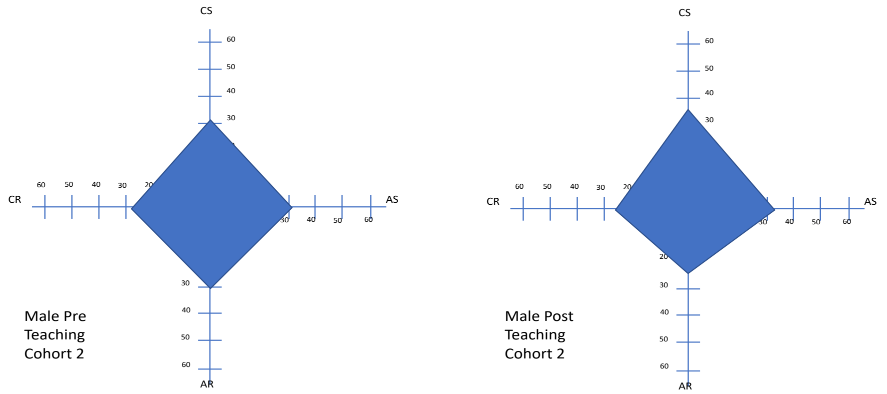
Fig 4.20 Thinking style data by Gender postgraduate cohort 1 - Female



Differences from a female perspective using averaged scores - CS & AR remain almost the same, a small drop in CR and a larger rise in AS moving away from experimentation and towards theory and orderly thinking overall.

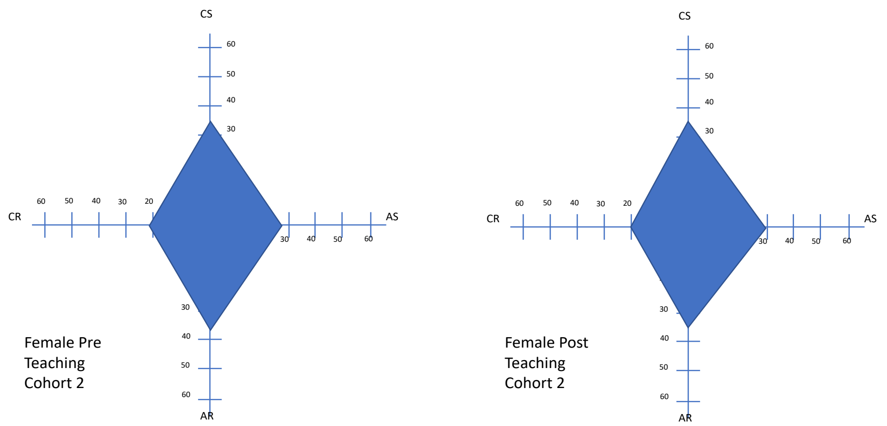
Postgraduate cohort 2 grouped responses by gender are presented in Figures 4.21 and 4.22.

Fig 4.21 Thinking style data by Gender postgraduate cohort 2 - Male



From a male perspective using averaged scores - only minor drops in CS & AS, a larger drop in AR and a small drop in CR moving from reflection and experimentation to more sequential, theoretical and orderly thinking overall.

Fig 4.22 Thinking style data by Gender postgraduate cohort 2 - Female



Differences from a female perspective - CS & CR remain almost the same, a small drop in AR and a small rise in AS moving away from reflection and towards theory and orderly thinking overall.

The data for thinking style questions had to be processed, as seen in Section 3.4, Figures 3.3 and 3.4, and then converted to obtain graphical outputs. Due to this processing the thinking style data has not been tested for internal consistency and reliability measures or through using non-parametric tests.

Although the above findings are small, the main difference between undergraduate cohort 1 and cohort 2 is that passive teaching seems to have encouraged a more reflective thinking style with less use of experimenting in males but the opposite in females whereas active teaching seems to have encouraged more reflective, experimental thinking in all respondents. For postgraduate males there is a difference between cohort 1 and 2 in that cohort 2 males have moved away from reflection and experimentation towards sequential, theoretical and orderly thinking which is opposite to cohort 1 male responses. Females responses in both cohorts are similar to each other with only minor differences.

4.3.4 Tests for Hypothesis 4 – Self-Esteem impact.

H4 – A learner's belief in their current abilities (self-esteem) is affected by being exposed to an active teaching approach.

Descriptive Statistics.

Mean scores for self-esteem in undergraduate cohort 1 have all risen (some only very slightly) from pre to post teaching tending to indicate more belief in their current capabilities (Table A10.8a). Standard deviation, Skewness and Kurtosis measures for undergraduate cohort 1 vary quite a lot but there are no obvious patterns evident.

Means for most of the self-esteem items in undergraduate cohort 2 have also risen from pre to post teaching. However, means for the items 'achieving aims', 'being calm under stress', 'acceptance of challenges', 'thinking around a problem' and 'making sensible judgments' have fallen. Standard deviation values are relatively stable but Skewness and Kurtosis measures for cohort 2 vary quite a lot. There are no obvious patterns evident but there are some rather large changes (Table A10.8b).

Means for the Self-Esteem category for postgraduate cohort 1 also show a rise for all items but a mix of rise and fall for cohort 2. Skewness and Kurtosis measures also show differences but whilst there are no discernible trends for either cohort, the cohort 2 results do indicate a more polarised response with more clustered responses for some items. Tables A10.57a and A10.57b refer.

Gender Differences – Undergraduate Cohorts

Results for the self-esteem category for undergraduate cohort 1 show that males retain a significantly non-normally distributed data response where females move to normally distributed profiles post teaching for six items whilst one item, 'Acceptance of Challenges', moves to a non-normally distributed response (Table A10.13a). For cohort 2 we again see male responses as non-normally distributed at both pre and post data collections but for females there are five items moving from normal to non-normally distributed and also five other items moving from non-normal to a normally distributed profile (Table A10.13b). Use of active teaching is shown here to have a similar effect on gender as passive teaching.

Assuming a null hypothesis of no differences between genders, an independent samples Mann-Whitney U test found no indications of gender differences (null hypothesis retained in all cases) either cohort 1 or cohort 2 – see Tables A10.18a and A10.18b. However, one item in the self-esteem category for cohort 2 moves from very near to significant pre-teaching (.050) to non-significant post teaching (.169) see Table 4.50 mean scores.

Table 4.50 Undergraduate gender differences for self-esteem cohort 2.

Self-Esteem Category Item	Male average Pre to post	Female average Pre to post	Comment
Problem solving (Sig values move from Pre .050 to Post .169)	Pre – 3.81 Post – 3.92	Pre – 3.25 Post – 3.29	Both males and females seem to have grown slightly more confident thus no direct indication why this result moved away from significance.

Gender Differences – Postgraduate Cohorts

Postgraduate results for gender differences in the self-esteem category are reproduced here (Table 4.51) full results in Tables A10.67a and A10.67b. Testing for significant differences in the distribution of data between genders for postgraduate cohort 1 was carried out, with the null hypothesis of maintaining no difference between genders. Each item that resulted in a significant difference is set out below where indications of gender differences (null hypothesis not supported) are highlighted.

Table 4.51 Hypothesis tests for postgraduate gender differences in self-esteem.

Self-Esteem Category Item	Mann-Whitney U			
	Cohort 1		Cohort 2	
	Pre	Post	Pre	Post
Resourcefulness	.007	.433	.780	.262
Sticking to my plans	.027	.495	1.000	.697
Sticking to my plans 2	.020	.596	.985	.857
Achieving aims/goals	.138	.596	.117	.004

It was not clear why these items should even out in terms of gender distribution so looking at means show possible reasons for the results (Table 4.52).

Table 4.52 Means comparison for postgraduate gender differences in self-esteem.

Scale	Question	Means for significant items		
		Male Cohort 1 Pre to Post	Female Cohort 1 Pre to Post	Comment
Self-esteem Cohort 1	Resourcefulness	3.25 to 3.95	3.93 to 4.10	Confidence in their ability to achieve their aims is increased in males and females showing a significant change in perspective for both genders. This seems more pronounced in males thus there could be a different effect for males than females where passive teaching is employed.
	Sticking to my plans	2.55 to 3.45	3.29 to 3.70	
	Sticking to my plans 2	3.30 to 3.95	4.07 to 4.10	
		Male Cohort 2 Pre to Post	Female Cohort 2 Pre to Post	
Self-esteem Cohort 2	Achieving aims/goals	3.77 to 4.00	3.52 to 3.30	Confidence in their ability to achieve their aims is increased in males but decreased in females showing a significant change in perspective between genders.

The above means could indicate a difference between males and females when exposed to active teaching as compared to passive teaching

Age Related Differences – Postgraduate cohorts only

There are a good number of changes evident when investigating differences by age group, all of them are applied to the 25-34 year old range. Table 4.53 shows the significant changes for cohort 1 for self-esteem split by age. Full results are shown in Table A10.73a. Cohort 2 results are more stable see Table 4.54 below and Table A10.73b.

Table 4.53 Postgraduate responses of their confidence in their current abilities (Self-Esteem) split by age for cohort 1.

Tests of Normality				
	Age at last birthday	Shapiro-Wilk		
		Statistic	df	Sig.
Problem Solving	25-34 – pre	.866	6	.212
	25-34 – post	.640	6	.001
Getting Resources	25-34 – pre	.640	6	.001
	25-34 – post	.827	6	.101
Achieving aims/goals	25-34 – pre	.701	6	.006
	25-34 – post	.866	6	.212
Deal with unexpected events	25-34 – pre	.640	6	.001
	25-34 – post	.827	6	.101
Investing the appropriate effort	25-34 – pre	.640	6	.001
	25-34 – post	.866	6	.212
Being calm under stress	25-34 – pre	.640	6	.001
	25-34 – post	.805	6	.065
Acceptance of challenges	25-34 – pre	.866	6	.212
	25-34 – post	.496	6	.000
Sticking to my plans 2	25-34 – pre	.907	6	.415
	25-34 – post	.683	6	.004

Three items move from normal distribution before teaching to non-normal afterwards whereas five items move in the other direction. ‘Problem solving’, ‘sticking to my plans’ and 'acceptance of challenges' seem to be recognised as less certain after passive teaching. Although the small number of respondents might be skewing these results disproportionately, it is worth noting there is a seeming difference for older members of the cohort.

Table 4.54 Postgraduate responses of their confidence in their current abilities (Self-Esteem) split by age for cohort 2.

Tests of Normality				
	Age at last birthday	Shapiro-Wilk		
		Statistic	df	Sig.
Sticking to my plans	25-34 – pre	.941	9	.595
	25-34 – post	.658	9	.000
Being calm under stress	25-34 – pre	.781	9	.012
	25-34 – post	.838	9	.055
Acceptance of challenges	25-34 – pre	.813	9	.028
	25-34 – post	.913	9	.338
Sticking to my plans 2	25-34 – pre	.833	9	.049
	25-34 – post	.805	9	.024

It is interesting to note that the item 'sticking to my plans' did not change distribution for this age group in cohort 1 even though the related item 'sticking to my plans 2' did. For cohort 2 the item 'sticking to my plans' moves to a non-normal distribution, joining its related item. The items 'being calm under stress' and 'acceptance of challenges' have moved from significant to non-significant pre to post teaching. This probably reflects the level of maturity and previous experiences of the respondents, either in employment or previous study. All other items in this category have remained the same for cohort 2.

Previous experience of teaching style related differences – postgraduate only

Looking at specific responses from a teaching style perspective full results for the self-esteem category for cohort 1 are contained in Table A10.79a but the one significant result is also reported in Table 4.55.

Table 4.55 Hypothesis tests postgraduate cohort 1 of teaching style differences in self-esteem.

Self-Esteem Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Thinking around a problem	.014	.584	Highly less significant

Table 4.55 shows one item which has moved from a significant distribution based on experience of teaching styles to a strongly non-significant value. The mean scores from pre to post teaching for this item are shown in Table 4.56.

Table 4.56 Means comparisons postgraduate cohort 1 of teaching style differences in the self-esteem category.

Self-Esteem Category Item	Passive experience average	Active Experience average	Comment
Thinking around a problem	Pre – 3.30 Post – 3.90	Pre – 4.07 Post – 4.09	Students experienced in passive teaching seem to have grown more confident whilst those with previous experience of active teaching have retained their confidence. This convergence between the students' experience of the two styles of teaching may explain the result.

There were also some changes noted for cohort 2 (Table A10.79b for full results)..

Table 4.57 Hypothesis tests postgraduate cohort 2 of teaching style differences in self-esteem.

Self-Esteem Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Getting resources	.791	.011	Highly more significant
Coping with uncertainty	.002	.236	Moderately less significant
Relying on oneself	.105	.965	Very highly less significant

Table 4.57 shows that confidence in 'getting resources' moves strongly from non-significant to significant whilst confidence in 'coping with uncertainty' moves in the other direction. One item in the self-esteem arena that stands out here, although it is not in the significant

category is the item ‘relying on oneself’ which has moved from an almost significant distribution between teaching styles to the opposite end of the spectrum.

To summarise, there are clearly different effects from passive and active teaching. For cohort 1 both males and females were more positive about their confidence in being resourceful and sticking to their plans but the male response was more pronounced. For cohort 2 however, the only effect seen was a rise in male belief in achieving their goals but a corresponding fall in female belief in the same item. Age related differences are almost entirely confined to older respondents (25-34 year old age group) where two items show a different response between actively and passively taught cohorts. The items ‘being calm under stress’ and ‘acceptance of challenges’ become weaker during passive teaching but stronger during active teaching. The item ‘sticking to my plans 2’ grows stronger and shows a similar trend for both cohorts but is more pronounced during passive than active teaching.

Non-Parametric tests – Undergraduate cohorts

The results for Wilcoxon Signed Ranks tests and paired sample tests for undergraduate respondents are contained within Tables 4.32 to 4.35 in Section 4.3.1 above. These have been discussed from an active vs passive teaching perspective however the only significant results for self-esteem within each of the cohorts is for students experiencing the active teaching style in cohort 2 (Tables 4.58 and 4.59).

Table 4.58 Wilcoxon Signed Rank Test for self-esteem for undergraduate cohort 2

Scale	Question	Significance	Z	n	R - effect	Effect Size	Mean Pre to Post
Self-esteem Cohort 2	Being calm under stress	.028	-2.200	50	-.357	Medium	4.00 to 3.74
	Sticking to my plans 2	.034	-2.123	50	.338	Medium	3.05 to 3.35
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation pre to post teaching is reported according to Cohen (1988).							

Table 4.59 Paired Sample Tests for self-esteem for undergraduate cohort 2.

Scale	**Question**	**Paired Samples Tests**					
		Mean Pre to Post	***SD***	***df***	***t***	***Sig. (2-tailed)***	***Effect Value (Eta squared)***
Self-esteem Cohort 2	Being calm under stress	4.00 to 3.74	.727	42	2.308	.026	.112 (Medium)
	Sticking to my plans 2	3.05 to 3.35	.887	42	-2.234	.031	.106 (Medium)
Effect size (eta^2) is explained above and is given by: t^2 / (t^2 + df).							

Tables 4.58 and 4.59 both show a significant reduction in student perception of their ability to remain calm under stress but a significant rise in their ability to stick to what they have planned for pre to post teaching.

Data on respondents' previous experience of Passive/Active teaching was not collected at undergraduate cohort 1 so cannot be reported upon – this error was corrected for when collecting data for cohort 2. There are no indications that previous educational experience has affected undergraduate respondents' self-esteem during active teaching.

Non-Parametric tests – Postgraduate cohorts

Postgraduate responses were previously reported (see Tables 4.36 to 4.39 in Section 4.3.1). Cohort 1 tests showed 12 of the 15 items in this category to have significant differences between pre and post teaching responses. Table A10.76c shows a comparison of all results and it is interesting to note that only one item for postgraduate cohort 2 showed any significant change. Table 4.60 and Table 4.61 pick out the one item that qualifies in the self-esteem category for cohort 2. Means are reported to try and identify the direction of change, effect sizes are estimated using Cohen's (1988) criteria for effect size where 0.1 = small, 0.3 = medium and 0.5 = large.

Table 4.60 Wilcoxon Signed Rank Test significant differences (postgraduate cohort 2).

Category	Question	Sig.	Z	n	R - effect	Effect Size	Mean Pre to Post
Self-esteem	Generating solutions to problems	.036	-2.100	47	.328	Medium	3.55 to 3.81
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation (effect size) is reported according to Cohen (1988).							

Table 4.61 Paired Sample Tests for self-esteem for cohort 2.

Scale	Question	Paired Samples Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect Value (Eta squared)
Self-Esteem	Generating solutions to problems	3.55 to 3.81	.793	46	-2.207	.032	.096 (Medium)
Eta^2 – effect value is given by: $t^2/(t^2 + df)$. Effect size for the paired samples test is discussed below.							

Tables 4.60 and 4.61 indicate a medium sized rise in the respondents' confidence in generating solutions to problems after experiencing active teaching. The overall number of changes for postgraduate cohort 1 is greater than that seen for cohort 2 and could indicate active teaching actually has less of an effect than was thought to be the case.

Summarising the findings from this section we have seen that males do not seem to be affected in their perceptions of their ability to carry out tasks, regardless of the teaching style adopted. Females on the other hand do seem to be affected in some items by an active teaching style.

4.3.5 Tests for Hypothesis 5 – Self-Efficacy impact.

H5 – The learner experiences a rise in their level of self-efficacy and takes more responsibility for their own learning when exposed to an active teaching approach.

Descriptive Statistics.

For the self-efficacy category, differences between the means for undergraduate cohort 1 shown in Table A10.9a and their respective 5% trim values are minimal showing no impact from extreme values. However, four items 'finish reports', 'use the library', remember engineering design lectures' and 'remember engineering design practical' show a reduced mean while all others show rises or remain the same.

The only item showing a dramatic change for undergraduate cohort 2 (Table A10.9b) is reproduced in Table 4.62 below. The 'remember engineering design lecture content' change is due to one outlier that when removed also removes these wild extremes in standard deviation, skew and kurtosis. All other item means remain similar between data collections, some rise and fall slightly but all remain at or move towards a non-normally distributed value.

Table 4.62 Undergraduate responses of their confidence in their future abilities (Self-Efficacy) split by data collection for cohort 2.

Self-Efficacy Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Remember 'Engineering Design' lecture content	Pre	4.40	5.350	9.145	85.686
	Post	3.30	1.015	-.524	-.103

Postgraduate responses for the Self-Efficacy category show a rise in mean score for all but two items for cohort 1 but a fall of all but four items for cohort 2. Skewness and Kurtosis measures also show differences and there are no discernible trends for either cohort. This tends to indicate less certainty in postgraduate respondents exposed to active teaching. Tables A10.58a and A10.58b refer.

Gender differences – Undergraduate cohorts

Results for the undergraduate self-efficacy category for cohort 1 show that most items for female students are normally distributed with the exception of ‘taking class notes’ which changes from normal pre-teaching to a non-normally distributed profile post teaching. The item for ‘Document technical procedures…’ changed from non-normally distributed pre-teaching to normally distributed post teaching. For males, all results remain non-normally distributed (Table A10.14a). For undergraduate cohort 2 there are a number of differences shown in data distribution but again all for female respondents, male responses remained non-normally distributed at all times. Table A10.14b has details showing items for ‘finishing reports or assignments on time’, ‘taking class notes…’, motivating yourself to study engineering’, ‘taking part in class discussions’, designing and constructing an experiment…’ and documenting technical procedures…’ all moving from normal to non-normal distribution with only one item ‘remember engineering design lecture content’ moving in the opposite direction.

In testing for significant differences in the distribution of data between genders for undergraduate cohort 1 from pre to post teaching responses, with the null hypothesis of maintaining no difference between genders, an independent samples Mann-Whitney U test found there were three indications of gender differences overall, one item

‘Concentrate on technical engineering subjects’ moved from a significant result (.036) pre-teaching and became non-significant (.682) post teaching. Two other items moved into significance post teaching, Table A10.19a shows all results and those values that moved into significance post teaching compared to pre-teaching are shown in Table 4.63 with associated commentary.

Table 4.63 Hypothesis tests showing significance for undergraduate cohort 1 gender differences of self-efficacy.

Self-Efficacy Category Item	Male average Pre to Post	Female average Pre to Post	Comment
Remember 'Engineering Design' lecture content Significance values Pre = .176 Post = .014	Pre – 3.70 Post – 2.80	Pre – 2.60 Post – 4.30	Males seem to have grown less confident whilst females have become much more confident for this item, leading to a combined effect that might have produced this move to significance.
Remember 'Engineering Design' practical session outputs Significance values Pre = .061 Post = .031	Pre – 3.76 Post – 3.32	Pre – 2.875 Post – 4.33	This question exhibits a similar pattern of male vs female confidence as above.

For cohort 2, there were no statistically different results when testing across genders but a combined effect was noticed where males grew more confident and females less so for the item ‘review instructions and estimate how long it will take to complete an engineering task’ leading to a result that whilst not statistically significant was highly more significant (see Table 4.64 and Table A10.19b).

Table 4.64 Undergraduate gender differences for self-efficacy for cohort 2.

Self-Efficacy Category Item	Male average Pre to Post	Female average Pre to Post	Comment
Review instructions and estimate how long it will take to complete an engineering task Pre = .644 Post = .108	Pre – 3.68 Post – 3.72	Pre – 3.50 Post – 3.29	Males seem to have grown more confident whilst females less confident so the combined effect might have resulted in this tendency towards significance

Data on respondents' previous experience of Passive/Active teaching for undergraduate cohort 2 indicate no statistically different results between genders (Table A10.25).

The main finding from undergraduate responses is that male respondents exhibit no change in significance for any tests but that female respondents are affected in some cases.

Gender differences – Postgraduate cohorts

For postgraduate responses in the self-efficacy category, tests for normality in cohort 1 indicate two items where female students show significant changes (Table 4.65) – 'taking class notes…' shows more confidence and could be due to the respondents becoming generally more familiar with this activity and putting in coping strategies for the future but 'leading a technical team…' has moved into significance, also probably due to the experience of having to work in teams during the term on non-lecture based aspects. Males indicated no changes in any item for this category (Table A10.63a). For cohort 2, there were no changes to the data distribution in any items, all remained firmly non-normally distributed (Table A10.63b).

Table 4.65 Normality tests cohort 1 for postgraduate responses of their self-efficacy.

Self-Efficacy Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Take class notes that will be useful in technical or engineering projects	Pre	.000	.040
	Post	.001	.149
Lead a technical team to develop a new product to a successful result	Pre	.046	.088
	Post	.001	.036

Testing for significant differences in the distribution of data between genders with the null hypothesis of maintaining no difference between genders, an independent samples Mann-Whitney U test comparing median scores for these data sets highlights one change for cohort 1 and three changes for cohort 2.

Table 4.66 Hypothesis tests of postgraduate gender differences for the importance of self-efficacy – both cohorts.

Self-Efficacy Category Item	**Mann-Whitney U**			
	Cohort 1		**Cohort 2**	
	Pre	**Post**	**Pre**	**Post**
Remember 'Engineering Design' lecture content	.017	.298	.300	.752
Take part in class based engineering or technical discussions	.231	.596	.004	.136
Design and construct an experiment that maintains precisely specified conditions	.129	.375	.014	.916
Document technical procedures so that someone else could use them to produce the same result	.090	.463	.018	.296

Table 4.66 shows three items in cohort 2 with a statistically significant difference between genders pre-teaching that have now moved into a non-significant value post teaching. Further investigation was carried out to ascertain whether it was male or female views that contributed more to the initial statistic pre-teaching – results are shown in Table 4.67.

Table 4.67 Hypothesis test comparisons both postgraduate cohorts of gender differences in self-efficacy.

Self-Efficacy Category Item	Male average Pre to Post Cohort 1	Female average Pre to Post Cohort 1	Comment
Remember 'Engineering Design' lecture content	Pre – 3.10 Post – 3.93	Pre – 3.93 Post – 4.00	Males have moved quite a way towards the female position showing a far more closely aligned response between genders for this item after passive teaching.
	Male average Pre to Post Cohort 2	Female average Pre to Post Cohort 2	
Take part in class based engineering or technical discussions Results when Male outliers are removed from the analyses	Pre – 4.33 Post – 4.17 Pre – 4.55 Post – 4.28	Pre – 3.83 Post – 3.90	Males seem to have grown less confident whilst females more confident thus a combined effect that might have resulted in this shift. Controlling for one male outlier at each of pre and post teaching responses we still see the same shift in male confidence.
Design and construct an experiment that maintains precisely specified conditions Result when Female outlier at PG-t4 is removed from the analysis.	Pre – 4.13 Post – 3.67	Pre – 3.61 Post – 3.60 Post – 3.74	Males show a reduction in their confidence levels but females remain virtually unchanged. Controlling for one female outlier post teaching indicates females have become more confident - the overall effect may account for the move from significant to highly less significant.
Document technical procedures so that someone else could use them to produce the same result	Pre – 4.13 Post – 3.73	Pre – 3.65 Post – 3.55	Males seem to have moved towards the female position here but both genders appear less confident post teaching.

The main findings from this section are that male respondents show no change in significance for any tests yet there are some for female respondents. These results indicate a general tendency for male and female respondents to be more aligned in their views after teaching in both passively and actively taught cohorts.

Age Related Differences – postgraduate cohorts only

Testing for differences between age groups in postgraduate cohorts identified some changes for older respondents and one change for the 18-24 year range. Tables 4.68 and 4.69 present the changed results.

Table 4.68 Postgraduate responses of their confidence in their future abilities (Self-Efficacy) split by age for cohort 1.

Tests of Normality				
	Age at last birthday	Shapiro-Wilk		
		Statistic	df	Sig.
Finish reports or assignments on time	25-34 – Pre	.683	6	.004
	25-34 – Post	.827	6	.101
Remember 'Engineering Design' lecture content	25-34 – Pre	.683	6	.004
	25-34 – Post	.853	6	.167
Motivate yourself to study engineering	25-34 – Pre	.866	6	.212
	25-34 – Post	.496	6	.000
Review instructions and estimate how long it will take to complete an engineering task	25-34 – Pre	.827	6	.101
	25-34 – Post	.496	6	.000
Lead a technical team to develop a new product to a successful result	18-24 – Pre	.915	20	.078
	18-24 – Post	.813	20	.001
Document technical procedures so that someone else could use them to produce the same result	25-34 – Pre	.960	6	.820
	25-34 – Post	.496	6	.000

For older respondents, results for ‘finish reports…’ and ‘remember engineering design…’ move out of significance whilst ‘motivating yourself…’, ‘reviewing instructions…’ and ‘documenting technical procedures’ become significant. The one change for the 18-24 year grouping indicates that leading a technical team has become more uncertain i.e. distribution of data is less polarised, a greater range of responses.

Postgraduate cohort 2 responses (Table 4.69) show there are a number of differences between responses in the 25-34 age range (Tables A10.74a and A10.74b for full results). These results may be more sensitive due to the small number of responses but nevertheless do indicate shifts from non-significant to significant in remembering 'engineering design' lecture content, ‘taking part in class based engineering or technical discussions’ and in ‘writing a clear and concise engineering project plan’. Moves in the other direction are shown in just one category where 'designing and constructing an experiment that maintains precisely specified conditions' moves away from significance.

Table 4.69 Postgraduate responses of their confidence in their future abilities (Self-Efficacy) split by age for cohort 2.

Tests of Normality				
	Age at last birthday	Shapiro-Wilk		
		Statistic	df	Sig.
Remember 'Engineering Design' lecture content	25-34 – Pre	.838	9	.055
	25-34 – Post	.833	9	.049
Take part in class based engineering or technical discussions	25-34 – Pre	.838	9	.055
	25-34 – Post	.808	9	.025
Design and construct an experiment that maintains precisely specified conditions	25-34 – Pre	.780	9	.012
	25-34 – Post	.873	9	.132
Write a clear and concise engineering project plan	25-34 – Pre	.903	9	.273
	25-34 – Post	.655	9	.000

Teaching style related differences – postgraduate only

The self-efficacy category shows a few more changes and is available in full at Table A10.80a but the significant items are shown below in Table 4.70.

Table 4.70 Hypothesis tests postgraduate cohort 1 of teaching style differences for self-efficacy.

Self-Efficacy Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Take class notes that will be useful in technical or engineering projects	.030	.938	Very highly less significant
Plan and organise your workload and technical study space	.017	.876	Very highly less significant
Remember 'Engineering Design' practical session outputs	.025	.876	Very highly less significant

Table 4.69 shows three items 'take class notes…', 'plan and organise work load…' and 'remember engineering design practical…' moving very strongly away from significance. These three items are analysed for their means pre to post teaching (Table 4.71) to try and identify why this might happen.

Table 4.71 Means comparisons postgraduate cohort 1 of teaching style differences in the self-efficacy category.

Self-Efficacy Category Item	Passive average Pre to Post	Active average Pre to Post	Comment
Take class notes that will be useful in technical or engineering projects	Pre – 3.15 Post – 3.90	Pre – 3.86 Post – 3.91	Similar to the effect seen in the self-esteem category item, students experienced in passive teaching seem to have grown more confident whilst those with previous exposure to active teaching have retained their confidence resulting in an almost identical mean value for those experienced in either style of teaching.
Plan and organise your workload and technical study space	Pre – 3.60 Post – 4.14	Pre – 4.36 Post – 4.18	We see a similar shift here to that noted above with a slight drop in confidence for those experienced in active teaching giving a combined effect that has resulted in this close value for each experience style.
Remember 'Engineering Design' practical session outputs	Pre – 3.05 Post – 3.95	Pre – 3.93 Post – 3.91	An almost identical pattern is seen here as in the items above.

Postgraduate cohort 2 saw some changes in this aspect as well.

Table 4.72 Hypothesis tests cohort 2 of teaching style differences for self-efficacy.

Self-Efficacy Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Finish reports or assignments on time	.721	.038	Highly more significant
Use the library and search engines for engineering research	.698	.045	Highly more significant
Plan and organise your workload and technical study space	.084	.965	Very highly less significant
Design and construct an experiment that maintains precisely specified conditions	.864	.198	Highly more significant
Lead a technical team to develop a new product to a successful result	.772	.055	Highly more significant
Write a clear and concise engineering project plan	.065	.016	Slightly more significant

Table 4.72 shows ‘finish reports’ and ‘use the library’ both moving strongly to significance and a much smaller yet still significant move in ‘write a clear and concise plan’. Items for ‘design and construct …’ and ‘lead a technical team…’ have moved strongly towards significance. However, the item ‘plan and organise …’ has moved strongly away from significance. Table A10.80b has full results but these interesting results from Table 4.72 were compared by looking at averages per teaching style and the results are commented on in Table 4.73.

Table 4.73 Means comparisons postgraduate cohort 2 of teaching style differences in the self-efficacy category.

Self-Efficacy Category Item	Passive average Pre to Post	Active average Pre to Post	Comment
Finish reports or assignments on time	Pre – 4.48 Post – 4.58	Pre – 4.44 Post – 4.12	Students experienced in passive teaching have grown more confident but those experienced in active teaching less confident - a combined effect that might have caused this shift.
Use the library and search engines…	Pre – 4.21 Post – 4.48	Pre – 4.17 Post – 4.00	Similar shift is seen here to that noted above.
Write a clear and concise engineering project plan	Pre – 3.70 Post – 4.03	Pre – 4.17 Post – 4.47	Passive based learners have grown more confident and moved towards the considerably more confident active based learners position here.
Plan and organise your workload and technical study space	Pre – 4.09 Post – 4.16	Pre – 4.39 Post – 4.12	Passive based learners have grown in confidence where active based have dropped. Both are now very close to each other but it does not really explain the large shift towards non-significance.
Design and construct an experiment that maintains precisely specified conditions	Pre – 3.94 Post – 3.55	Pre – 3.94 Post – 3.88	Both learner styles appear less confident and after teaching are less closely aligned than before teaching. This could explain the strong move towards significance.
Lead a technical team to develop a new product to a successful result	Pre – 3.64 Post – 3.65	Pre – 3.67 Post – 4.12	Active based learners seem to have grown considerably more confident in leadership than passive based learners.

In summary there appears to be less certainty in respondents exposed to active teaching but overall gender balance is better after the teaching intervention, whether active or passive. Age related effects are once again confined to older respondents showing some more mature thinking. Where previous experience of active teaching is claimed, respondents seem to have grown even more confident in areas that require leadership but less so in areas that require structure and process. The opposite seems to be the case for those used to passive teaching. There is one exception, writing clear and precise project plans seems to be an area where all respondents have grown in confidence – a good sign when being taught project management but probably not an indicator of change!

Non-Parametric tests – Undergraduate cohorts

From a self-efficacy perspective, we saw no major changes for undergraduate cohort 1 but for undergraduate cohort 2 we note a significant drop in their ability to remember lecture content. Means are reported to try and identify direction of change.

Table 4.74 Wilcoxon Signed Rank Test for self-efficacy for undergraduate cohort 2.

Scale Category	Question	Significance	Z	n	R - effect	Effect Size	Mean Pre to Post
Self- Efficacy	Remember Engineering Design lecture content	.003	-2.922	50	-.211	Small	4.98 to 3.37
Effect size (R) is discussed below and is given by (post teaching mean – pre-teaching mean) / standard deviation.							

Table 4.74 indicates small effect size so confirmatory tests using paired sample tests and correlations were carried out. Table 4.75 summarises the findings. Eta squared is used to calculate the effect size based on Cohen (1988, pp.284-287). The effect measure indicates the percentage of variation in the item that is explainable through the choices made by a students' experience of teaching style. All these effects may not be attributable to the teaching approach but serve as a base line for comparison. No other items show any significant changes overall.

Table 4.75 Paired Sample Tests for self-efficacy for undergraduate cohort 2.

Scale Category	Question	Paired Sample Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect value (eta squared)
Self-Efficacy	Remember Eng' Design lecture content	4.98 to 3.37	7.619	42	1.381	.175	.043 (Small)
Effect size (eta^2) is explained above and is given by: UG-t2 / (UG-t2 +df).							

Looking at the final column in Table 4.75, 2-tailed t-tests reverse the significance results seen from the Wilcoxon signed rank tests. Even though 'remember engineering design lecture content' was not statistically significant in t-tests it reflects the small effect value we saw previously in Table 4.74.

Non-Parametric tests – Postgraduate cohorts

Postgraduate cohort 1 tests showed seven of the 14 items in this category to have significant differences between pre and post teaching responses. Table A10.76d shows a comparison of all results and it is interesting to note that only one item for cohort 2 showed any significant change. Tables 4.76 and 4.77 show the postgraduate cohort 1 changed items with their respective effect sizes and Tables 4.78 and 4.79 pick out the one item that qualifies in the self-efficacy category for cohort 2. Means are reported to try and identify the direction of change.

From Table A10.76d the changed items are extracted and displayed in Table 4.76 below.

Table 4.76 Wilcoxon Signed Rank Test postgraduate categories for cohort 1

Category	Question	Sig.	Z	n	R - effect	Effect Size	Mean Pre to Post
Self-Efficacy	Take useful class notes	.010	-2.563	66	-.315	Medium	3.67 to 4.04
	Use library & search engines	.041	-2.041	66	-.251	Medium	3.48 to 3.85
	Remember 'Eng. Design' lecture	.035	-2.106	66	-.259	Medium	3.37 to 3.85
	Remember 'Eng. Design' practical	.007	-2.711	66	-.333	Medium	3.48 to 3.96
	Design & construct an experiment	.031	-2.162	66	-.266	Medium	3.26 to 4.00
	Lead a tech' team	.005	-2.820	66	-.347	Medium	3.37 to 4.19
	Document tech' procedures	.001	-3.307	66	-.407	Medium	3.67 to 4.04
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation (effect size) is reported according to Cohen (1988).							

Paired sample tests and correlations (n = 27) for the same items were carried out. The results identified the same items, Eta squared is used to calculate the effect size based on Cohen (1988, pp.284-287).

Table 4.77 Paired Sample Tests postgraduate categories for cohort 1

Category	Question	Paired Samples Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect Value (Eta squared)
Self-Efficacy	Take useful notes	3.33 to 3.89	1.013	26	-2.850	.008	.253 (Large)
	Use library & search engines	3.67 to 4.04	.884	26	-2.178	.039	.154 (Large)
	Remember 'Eng. Design' lecture	3.48 to 3.85	.839	26	-2.294	.030	.168 (Large)
	Remember 'Eng. Design' practical	3.37 to 3.85	.802	26	-3.118	.004	.272 (Large)
	Design & construct an experiment	3.48 to 3.96	1.051	26	-2.380	.025	.179 (Large)
	Lead a tech' team	3.26 to 4.00	1.130	26	-3.407	.002	.308 (Large)
	Document tech' procedures	3.37 to 4.19	1.001	26	-4.228	.000	.407 (Large)
Effect value (eta^2) is given by $t^2/(t^2 + df)$.							

Using paired sample tests, the penultimate column in Table 4.77 shows a significant improvement in respondent's confidence in all of the self-efficacy items and the effect is calculated to be medium to large in all cases.

Table 4.78 Wilcoxon Signed Rank Test significant differences for postgraduate cohort 2.

Category	Question	Sig.	Z	n	R - effect	Effect Size	Mean Pre to Post
Self-efficacy	Take useful class notes	.001	-3.197	47	-.573	Large	4.40 to 3.91
Effect size (R) is given by (Z/√n) where the sign is ignored and the power of the correlation (effect size) is reported according to Cohen (1988).							

From Table 4.78 there appears to be a significant reduction in the perceived collective ability to do things in the future (self-efficacy) for the item 'take useful class notes' – this effect is large and thus indicates a strong relationship. The reliability profile for the self-efficacy item 'take useful class notes' shows an overall rise where the average inter-item correlation value changed from .207 pre-teaching to .315 post teaching. Effect sizes are estimated using Cohen's (1988) criteria and means are reported to try and identify direction of change. Given the above result, paired sample tests and correlations (n = 47) for the same items were carried out. The results identified the same self-efficacy item and Eta squared is again used to calculate the effect size.

Table 4.79 Paired Sample Tests for self-efficacy in postgraduate cohort 2.

Scale	Question	Paired Samples Tests					
		Mean Pre to Post	SD	df	t	Sig. (2-tailed)	Effect Value (Eta squared)
Self-Efficacy	Take useful class notes	4.40 to 3.91	.855	46	3.609	.001	.221 (Large)
	Write a clear and precise project plan	3.87 to 4.15	.722	46	-1.952	.057	.076 (Medium)
Eta^2 – effect value is given by: $t^2/(t^2 + df)$.							

Looking at the final column in Table 4.79, student perceptions of 'take useful class notes' shows a large decrease indicating the cohort as a whole has less confidence in their ability to do this as they progress on their course. This was an unintended effect and thus is a slightly surprising result. A near miss for significance is included in the self-efficacy scale for the item 'writing clear and precise project plans' because project management was the module through which the post-graduate students were studied. It indicates a medium sized rise in their confidence levels going forward even though not statistically significant.

4.4 Chapter summary.

Main findings for this section are summarised below.

Undergraduate:

- Means for the item 'design and production' fell for cohort 2 but interestingly, not as much as for cohort 1;
- Responses to the importance of skills category were less clustered for cohort 2 – opposite to cohort 1;
- Not all the means for the self-esteem category items rose for cohort 2 whereas they did for cohort 1;
- Self-efficacy was affected by an outlier in one item for cohort 2 whose removal corrected the result;
- Learning style was not affected – this was a surprise considering active teaching was expected to affect this more than passive teaching; and
- Thinking style shows a slightly more reflective preference for cohort 2 and that females appear to be affected more by active teaching in this respect than males.

Postgraduate:

- After exposure to both passive and active teaching, means for 'Design and Production' rose slightly as expected;
- Means for the importance of skills category are also higher after both styles of teaching;
- Means for the self-esteem category show a mix of rise and fall for cohort 1 (passive teaching) but have all risen for cohort 2 (active teaching);
- Means for the self-efficacy category show a mix of rise and fall for both cohorts;
- There are changes in results for older respondents in both cohorts but only one change for 18-24 year olds and this was in cohort 1;
- The preferred learning style by cohort remains broadly the same with a slight shift for females towards a visual learning preference;
- Thinking style has shifted slightly away from a reflective style for both cohorts;
- There are indications that gender responses may play a part in some of the findings;
- The passive teaching style adopted for cohort 1 postgraduate students appears to have induced a few changed responses for self-esteem and self-efficacy in

students who had already experienced a passive teaching style. This is interesting in that those who had experienced an active style previously were almost unaffected; and

- An unexpected finding for cohort 2 indicates a lowering of confidence in taking useful class notes that might be an unintended result of the flipped classroom process, especially when we see an expected rise in confidence for discussion (but only in older respondents).

The findings summarised for all undergraduate and postgraduate cohorts through this chapter will be discussed alongside the qualitative interview responses as appropriate in Chapter 5. Overall conclusions and next steps will be discussed in Chapters 6 and 7 to allow for all outputs to be thoroughly explored.

5. Undergraduate and Postgraduate comparisons - cohorts 1 and 2

5.1 Introduction

Before teaching was given to any of the cohorts, results from pre-teaching questionnaire responses of the populations surveyed indicated an almost identical pattern of responses for both undergraduate and postgraduate cohorts. Given that all cohorts were proportionally similar, any differences seen in post-teaching results might be due to the adopted teaching style providing evidence in support or rejection of relevant hypotheses.

It can be seen from the findings in Chapter 4, whilst testing for evidence to support or reject the stated hypotheses, most categories and items within them did not display significant differences between cohorts, possibly because most students were used to a didactic, passive teaching style. However, this chapter provides a comparison between the quantitative data findings from respective undergraduate and postgraduate cohorts, combined with qualitative data collected after each of the applied teaching interventions. Qualitative interviews were recorded and summaries of the responses extracted to provide a list, by respondent, of all the different responses obtained. Significant quantitative findings, briefly touched upon within the narrative of Chapter 4, are discussed below and include additional analysis from summaries of qualitative findings. The qualitative summaries, contained in Appendix 11, come from a total of four interviews held with cohort 1 undergraduate and postgraduate respondents and six interviews held with cohort 2 undergraduate and postgraduate respondents.

Section 5.2 discusses the internal consistency of the scales used for the research categories whilst Section 5.3 discusses these categories in the same order as they appear in the questionnaires – importance of knowledge, importance of skills, self-esteem, self-efficacy, learning/teaching style and thinking style. Support for hypotheses are indicated at the end of each sub-section as appropriate. Section 5.4 discusses non-parametric statistical tests carried out on the data. Findings from undergraduate and postgraduate cohorts have been set out separately within each category to allow for easy comparison between the two sets of students. Overall conclusions are set out in Section 5.5.

5.2 Internal consistency

Undergraduate cohorts

Internal consistency relates to the reliability of the scales used in the various categories of research carried out. Comparisons between undergraduate data collections from cohorts 1 and 2 are made using Cronbach's (1951) Alpha test values (see Table 4.1) and are shown in Table 5.1 below.

Table 5.1 Undergraduate responses reliability/consistency measures.

Category	Alpha Score by Data Collection					Commentary
	Cohort 1			Cohort 2		
	Pre	Post		Pre	Post	
Importance of knowledge for electronic engineers	.792	.798		.851	.801	Cohort 1 shows acceptable levels where cohort 2 shows good levels of internal consistency. No major changes from pre to post cohort 1 using a passive teaching approach but a slight drop in consistency for cohort 2 from pre to post using an active teaching approach.
Importance of skills for electronic engineers	.838	.951		.888	.850	Cohort 1 show a rise from pre to post into the excellent zone using passive teaching but another small drop in consistency levels in cohort 2 where active teaching was used.
Self-esteem	.834	.742		.832	.804	Both cohorts show a small drop. Cohort 1 drops from good at pre to acceptable at post where cohort 2 stays in the good category but indicates a small reduction in internal consistency
Self-Efficacy	.946	.889		.523 (.803 without outlier)	.864	Drops from excellent to good for cohort 1 but an odd result for pre for cohort 2 was traced to one outlier that when removed gave .803 thus an overall small consistency rise.

The overall results indicate as a minimum there is acceptable internal consistency with all of the scales used in the undergraduate data collections.

For the ‘importance of knowledge’ category the Design and Production item has three quite low correlation scores compared to the other five items and one of the tasks the students need to master is to design and produce an electronic product as a team. Given that this work will start in the following term, their respective teams have not worked together and they have had no practical experience of this when the responses were collected, the result obtained may simply indicate some worries or trepidation about the forthcoming task.

The skills category saw a change between cohorts where cohort 2 had slightly weaker correlations for the items ‘be creative’ and ‘solve problems’. One would expect with a more active teaching style the cohort to become more creative, more willing to discuss and tackle problems but there is little evidence of this, though there is some evidence of females growing more confident in their ability to question effectively:

> *“…report writing, asking good questions, problem solving and team working skills are more important than I thought...”.*
>
> **Cohort 2 Chinese female**

The self-esteem category for both data collections from cohort 1 identified items related to planning worth investigating, and post teaching the additional items for ‘being calm under stress’ and ‘generating solutions to problems’ also needed further investigation. Interviews indicated that planning and confidence in current abilities had risen overall:

> “…*I do not always stick to my plans but feel this may be a lack of communication…”.*
>
> **Cohort 1 Chinese female**

The self-efficacy item causing slight concern is ‘finish reports or assignments on time’ where both cohorts displayed a lowering of confidence but cohort 2 dropped into the statistically significant area. These results may be explained by the imminent need to hand in reports and take exams. There is no indication that gender differences could explain these results but they did indicate a strong move towards a more even distribution between genders. Investigation of the poor internal consistency pre-teaching suggested that it can be traced to one response to the item ‘remember engineering design lecture content' which, if removed, takes the reliability value to .803 and results in no negative correlations or other anomalies. This explains the result and is not surprising here because the respondents had not had any of these lectures at the time of the data collection and whilst this was not seen during cohort 1, it may mean that cohort 2 are more willing to analyse the question and be more accurate with their responses.

Postgraduate cohorts

The summary of internal consistency values is produced as per undergraduate cohorts with a similar short commentary within Table 5.2 followed by a slightly longer review.

Table 5.2 Postgraduate responses reliability/consistency measures.

Category	**Alpha Score by Data Collection**					**Commentary**
	Cohort 1			Cohort 2		
	Pre	Post		Pre	Post	
Importance of knowledge for electronic engineers	.944	.834		.894	.536	Cohort 1 shows excellent to good levels cohort 2 shows good to poor levels of internal consistency. Cohort 1 using a passive teaching approach seem able to deal with this category but a major drop in consistency for cohort 2 pre to post active teaching is noted.
Importance of skills for electronic engineers	.944	.768		.924	.749	Cohorts 1 and 2 both show a drop from excellent to acceptable consistency indicating neither passive nor active teaching impacted differently on the importance of skills for engineers.
Self-esteem	.774	.820		.872	.773	Cohort 1 shows a small rise but cohort 2 a small drop in internal consistency.
Self-Efficacy	.838	.855		.851	.865	Both cohorts retain the same good internal consistency regardless of the style of teaching used.

Use of discussion in cohort 1 was very limited compared to the same in cohort 2 and results indicate no major changes thus no impact is evident through the use of different teaching approaches on the perceived importance of knowledge or skills. This result is surprising because inter-item correlations are more pronounced for active teaching than they were for the standard teaching approach. Possibly, the active teaching approach has introduced significant doubts in respondents regarding the importance of this knowledge for engineers. However, looking at means that are very similar there is nothing to strongly indicate why the scale indicates poor consistency post teaching other than it could be that there is an effect through using a different teaching approach. This was not anticipated. No other reason for the poor reliability indication is evident, all means look comparable pre to post and there are no outliers or data values outside of the accepted ranges. Each item was removed from the analysis systematically and no major improvement was achieved thus specific items do not seem to be affecting the overall reliability of the scale as a whole post teaching. Thinking about this item, one of the tasks the students need to master is to design and produce a marketing pitch for a technical product to obtain investment funds as a team. Similar to undergraduate cohorts, the result obtained may simply indicate some worries or trepidation about the task they are about to start, how the budget will pan out, how the team will work together and how the market views the product. Post teaching this item shows consistent results and whilst it is not alone in having lower overall correlation scores this could be due to the experience of studying and experiencing many of the items in this category during the taught period.

Looking at skills the students need to master, two items for cohort 2 (both post teaching), ‘communicate effectively’ and ‘using discussion to investigate an issue’ show negative correlations. This could indicate that these items may be related and that those exposed to active teaching were affected more. Another item of interest is team-working and given that team-working is part of the module but also that active teaching has placed more responsibility on the individual student to prepare for lessons, the competing pressures on their time may have led to a reduction in practical experience of team-working for cohort 2 compared to cohort 1. This might be an unintended result of active teaching but the need for specific team working skills is questioned in a comment:

> “*…search for information skill is needed as a skill… need to be independent in your learning…*”,
>
> **Cohort 1 Chinese female**

indicating support for more independent learning rather than team-based efforts.

Self-esteem differences in internal consistency measures between cohorts can be explained by considering that the challenge the respondents had just completed (project planning) was very daunting. For cohort 1 the students had more time to discuss in teams as there was no direct expectation for them to carry out significant self-study between lessons. Cohort 2 however, were expected to prepare for lessons and thus had less time to work in their teams. These aspects may have challenged their respective abilities to work in teams within the module, especially in cohort 2 where active teaching was introduced and thus reduced their confidence for tackling future project modules. A few items were identified that actually show aspects I would expect as their teacher such as lack of confidence in getting resources, dealing with unexpected events, thinking around and then generating solutions to a problem and finally making sensible judgments. There is some indication that the item 'relying on oneself' post teaching is not actually measuring self-esteem on the same scale as other items and this might be due to a realisation that one has to really rely on oneself at the postgraduate level as assessments and workloads increase:

> *"…not sure if the teaching has caused this but results have given me greater belief in myself to stick to my plans, do things and be more flexible…"*
>
> **Cohort 2 EU male**

This supports the upturn of self-reliance. The overall result being a lowering of consistency for the actively taught cohort 2. Overall results may indicate at least some effect is present through the use of active teaching.

Self-efficacy – there is a significant reduction in the perceived ability to do things in the future for the item 'taking class notes' for cohort 2. This effect is large and thus indicates a strong relationship. The reliability profile for the same self-efficacy item 'take useful class notes' shows an overall rise where the average inter-item correlation value changed from .207 pre-teaching to .315 post teaching. This may well be due to the fact that they have experienced lots of active lectures, notes are given up-front for them to read and discuss and so the result may be a lessening of their willingness and ability to capture key points in their notes during class. Interestingly this is not reflected in an improvement in their reflective thinking preferences. Of interest in the self-efficacy category are the items that showed a statistically significant difference between genders pre-teaching that have now moved into a non-significant value post teaching. The three items 'taking part in class-based discussions', 'design and construct an experiment' and 'document technical procedures' are all items that have been introduced and debated through the flipped classroom approach in the project management module. The indication here is that by being exposed to these items on a regular basis has led to the students being more comfortable in their use of class-based discussion resulting in a more balanced viewpoint. Interestingly none of the three items were identified as showing significant changes in the paired sample t-tests. The self-efficacy items ‘finish reports or assignments on time’ and ‘use the library and search engines for engineering research’ moved strongly to significance in cohort 2 and the much smaller yet still significant move in ‘write a clear and concise engineering project plan’ can all be explained by the imminent requirement for assignments to be handed in. Items for ‘design and construct an experiment…’ and ‘lead a technical team…’ moved towards significance but not quite into the significant category. However, the item ‘plan and organise your workload and technical study space’ moved strongly away from significance and this is opposite to what was expected since other significant results in this category seem to indicate that planning was difficult to achieve. Comments indicate that planning is key:

> “…*I think of steps to the future (planning) now rather than waiting for things to happen...”.*
>
> **Cohort 1 EU male**

Learning style consistency results are not good overall but one could surmise that the scale for determining learning style preference is not consistent between different teaching styles, even within a cohort of respondents. Alternatively, it is simply an indicator of preference with little actual relevance, as previously discussed in Chapter 2. Usefulness of learning style preference data is still debated (Coffield et al, 2004; Thompson-Schill et al, 2009; Dunn et al, 1984; Kolb, 1984; Kolb, 1999; Honey and Mumford, 2000; Gardner, 1993; Goleman, 1995; Mayor and Salovey, 1997; McCaulley, 2000; Willingham et al, 2015; Norman, 2009; Cuevas, 2015) with no clear outcome as yet and these results would appear to confirm the relative instability of using such a scale.

5.3 Comparison Categories

5.3.1. Importance of Knowledge to Engineers

Undergraduate Cohorts

Apart from an underlying feeling that team working required more communication skills (applied knowledge) than specific knowledge:

"…team work element was poor at first due to lack of knowledge in dealing with engagement",

Cohort 1 EU female

There were no specific changes indicated by either cohort:

"…all knowledge is important, combining engineering and business is good..."

Cohort 1 Chinese female

but post-teaching results show more differences for females in cohort 2 compared to cohort 1. For didactic or passive teaching (cohort 1) only one item (HRM) retained a normal distribution but for active flipped classroom teaching (cohort 2) a normal distribution was retained by two items 'accounting & finance' and 'legal aspects', gained for two items 'sales & marketing' and 'quality management' and lost for one item 'HRM'. Despite these differences, comments indicated:

"…yes, always important to have knowledge but quality management and team working seem more important now..."

Cohort 2 Chinese female

This shows similar feelings about knowledge for engineers as her equivalent from cohort 1. All seemed to agree that knowledge of management topics was important for engineers and no major changes were indicated.

One item 'design and production' showed an unexpected drop in mean score for both cohorts over the taught periods but the responses for standard deviation, skewness and kurtosis, for all data collections, for cohort 1 were opposite to those of cohort 2. Standard deviation showed a greater range of responses after teaching for cohort 1 but a smaller range for cohort 2. Similarly, skewness was more exaggerated for cohort 1 and less so for cohort 2 and kurtosis tended away from normal distribution values towards a peaked, central dispersion for cohort 1 but moved from highly peaked dispersion to an almost normal distribution in cohort 2. These differences were explored at interview but not evident in the responses:

"…the teaching has confirmed my earlier thinking and helped firm up my knowledge…"

Cohort 1 Chinese male

"…nothing much has changed in my view of the underlying importance of knowledge…the teaching has simply re-enforced my view".

Cohort 2 UK male

There is little if any support for the quantitative differences highlighted through responses at interview. The comment on teamwork in the above is probably because the module taught is a project module in which teamworking is an integral feature. In cohort 1, there is a noticeable focus on communication/recording and teamworking. There was a comment from a Chinese male in cohort 1 about HRM being useful for electronics engineers outside of university but the respondent seems to have missed the point of skills development through the acquisition of new knowledge. The Chinese female from cohort 2 who felt that team working and managing quality were key features of the knowledge gained through the taught aspects (see above) indicates some support for the wider finding that females seem more willing to offer their opinions. The above tends to lessen support for hypothesis H1 in that there is no evidence of there being either a positive or a negative change in undergraduate students' desire to learn (new knowledge) that can be attributed to active teaching.

Postgraduate Cohorts

The questionnaire responses suggest a significant improvement in respondents' views of the importance of knowledge in design and production for cohort 2 with a medium effect size indicating the strength of the relationship between the two measures is good (Table 4.38). This aspect was investigated at interview with no specific response to indicate why this item in particular showed a statistically significant change. Responses did indicate some more generic trends towards knowledge used for skills development:

"…need knowledge to improve your ability or skill level…"

Cohort 1 EU female

"…the need for knowledge is more than I thought it would be but mainly used to develop skills…" **Cohort 1 EU male**

However, cohort 1 responses did get closer to indicating support for the quantitative finding from cohort 2:

"… knowledge of creative idea generation is needed… theory is very important…"

Cohort 1 Chinese female

It is not clear why no one else from cohort 2 made a similar observation. All respondents saw the need for enhanced knowledge and two in particular felt that as their English improved, so did their level of understanding of the topic:

> *"…more enhanced now but not especially… probably due to level of English more..."*
>
> **Cohort 2 Chinese male**

> *"… more enhanced but not especially...could be due to language issues at first and now better understanding of the question helps…".*
>
> **Cohort 2 Mexican male**

Neither of the female respondents from China stated English language as being an issue:

> *"…no real changes but overall, knowledge seems more important in these areas..."* and *"…yes, now feel to be more important…"*
>
> **Cohort 2 Chinese females**

Another classmate was surprised by the importance of some items:

> *"…more important than at first, especially Sales and Marketing which was a surprise…".*
>
> **Cohort 2 UK female**

There is a tendency for all parties to see knowledge as more important than they first did with perhaps a slightly higher perception of this in Cohort 2. The overall desire to learn is improved in both cohorts, there are some gender differences evident and responses from older students indicate a slightly larger effect for those involved in active teaching (Tables A10.70a and A10.70b) thus lending some support to hypothesis H1.

Summing up, undergraduates tend towards lack of support for hypothesis H1 where postgraduates show an opposite tendency.

5.3.2. Importance of Skills in Engineers and opportunity to improve

Undergraduate Cohorts

In cohort 1 only one item was normally distributed pre-teaching, for females it is the ability to give effective presentations a result that was reversed post teaching:

> *"…females are generally not as forceful as males but my skills have changed in team working, writing and in presentation...I think I am better at communicating and skills seem easier to asses than knowledge…"*
>
> **Cohort 1 Chinese female**

> *"…some things have changed such as the importance of presentation and team working skills and I think it is easier to assess skills in the practical domain rather than subject knowledge…".*
>
> **Cohort 2 EU female**

However, females were less concerned after the teaching about producing quality reports or using discussion to investigate an issue:

> *"…it depends on the context and how it is explained but report writing, asking good questions, problem solving and team working skills are more important than I thought...".*
>
> **Cohort 2 Chinese female**

> *"…I have changed in odd ways, some (skills) feel more important... team working has made me realise we don't all need all of the skills, we can rely on others – presentations feel more important now..."*
>
> **Cohort 1 Chinese male**

> *"… liked the scope it gives on using hardware and software but need more practical experience…".*
>
> **Cohort 1 EU male**

> *"…not changed due to teaching but taken in context, there will always be changes…"* and another said *"…there is a high focus on team working skills that is probably missed by many students with no work experience…".*
>
> **Cohort 2 EU males**

This was further supported by a classmate who stated that his view of the importance of skills had:

> *"…not changed except for communication felt really important after all the teaching. Creativity is also important but mine didn't change. I think it is easier to asses someone's knowledge in a test or exam than their skills…".*
>
> **Cohort 2 EU male**

This tends to indicate males are keen on practical aspects and exam-based testing where quantitative results for females post teaching show they are more comfortable with creativity, formulating good questions and using discussion to investigate an issue than they were previously. This could point towards a more active teaching approach being effective in stimulating curiosity and willingness to question in females studying engineering. No male differences were identified.

Females seem to feel skills are easier to assess than knowledge yet males feel the opposite. When asked about the importance of having an opportunity to improve, cohort 1 respondents felt the key element that emerged was the ability to plan more effectively:

> *"…modules seem to bring positive stress because you can plan for assessments but exams bring negative stress. Not really planning, just revision.…"*
>
> **Cohort 1 EU male**

> *"…the teaching has helped me to see knowledge and skills development as interdependent on each other. I rely more on my own ability now than when I started the course… I am a better planner than I used to be…".*
>
> **Cohort 1 Chinese male**

This was not evident in cohort 2 responses where they all seemed to accept that improvement would happen. Comments from cohort 2 were abrupt and to the point:

> *"…the opportunity to improve is vital…", "…doesn't everyone want to improve?", "…everyone wants to improve…"* and *"…the opportunity to improve is key…".*
>
> **Cohort 2 various**

This may be reflected in a very slightly higher maturity ratio in cohort 2 where most interviewees in cohort 2 had at least some work experience compared with cohort 1 interviewees plus cohort 2 respondents were slightly older.

The short responses from cohort 2 interviewees reflected their ability to give direct answers, cohort 1 interviewees seemed to want to explain what had improved rather than offer a direct opinion. It is not clear whether this is due to cohort specific attitudes, the level of maturity of students or the different teaching styles experienced. There is some indication here that active teaching and the use of discussion in class may have had an effect whereby cohort 2 were more confident in stating their views. The above may have implications for hypotheses H1, H4 and H5.

Postgraduate Cohorts

In cohort 1 there were changes in six items within the importance of skills category for older respondents (Table A10.71a). However, for cohort 2 (Table A10.71b) there is only one significance change evident. These differences in students older than 24 between pre and post data collections are for communication aspects and solving problems. The reduction in the number of differences in cohort 2 could show more stability in postgraduate cohorts when an active teaching style is used.

The result for the ‘discussion’ item where 25-34 year olds in cohort 1 were less comfortable after the teaching, whilst not statistically significant, may have indicated that the lack of discussion in the class environment had an impact. Item correlation score for the ‘discussion’ item for both cohorts post teaching was below .300 and thus confirms the tendency. However, the same trend in this item, yet statistically significant result for cohort 2, indicates that teaching style does not appear to have been the cause for these class discussion changes. With such small respondent numbers however, (n = 6 in both cohorts for this item) it is difficult to find a meaningful output. This may indicate that active teaching has affected respondent views but there is no other supporting evidence for this. Males in postgraduate cohorts think that skills are harder to asses than knowledge:

> *“…it depends on your knowledge. It is easier for me to assess what knowledge I need (in order to) to develop new skills. Teachers explaining things has helped.…”*
>
> **Cohort 1 EU male**

However, females feel the opposite to be true:

> *“…it is easier to assess skills improvement but it depends on knowledge. Team-working through leadership skills are improved but not necessarily through the teaching…”*
>
> **Cohort 1 EU female**

"…effective presentations are necessary but not very important. Skills generally need developing…practice makes perfect…".

Cohort 1 Chinese female

The importance of having an opportunity to improve reinforced the view that planning is a key skill in preparing oneself for study. Cohort 2 responses indicated that the knowledge gained through lessons and private study was needed to develop the skill:

"…knowledge of skills seems more important now and skills are easier to assess…need communications skills, experiential learning is more valuable…"

Cohort 2 Chinese females

Their Chinese male classmate supported this view:

"…yes, I have changed, improved, especially in presentations. Practice is needed …"

Cohort 1 Chinese male

"…creativity is key but the environment is crucial – engineers cannot be good even if not creative. Knowledge is easier to assess…"

Cohort 1 Mexican male

Thus, knowledge and skills are related lending support to hypothesis H1.

Further questions were asked about the links between knowledge/skills and the importance of improvement and again we see descriptive statements from cohort 1 and more concise ones from cohort 2:

"…I am here because I want to be and the chance to improve knowledge and skill is great. Advice and guidance from teachers is key…planning and time management is much improved…learning how to be a leader without being bossy is even better…". **Cohort 1 EU female**

"…of course I want to improve and this course is helping me…".

Cohort 2 EU female

"…teaching has improved knowledge rather than skills but I see knowledge and skills as interdependent. Personal planning is good though as I am a better

planner now than I used to be…I rely more on my own abilities now than I did when I started the course…"

Cohort 1 Chinese female

"…knowledge and skills are related so these are improving and yes, I want to improve...".

Cohort 2 Chinese female

Responses from males were similarly phrased:

"…by doing you gain experience which gives improved ability...it is more about being taught how rather than what…I have a better focus now on what I need to do, planning is now seen to be key…"

Cohort 1 EU male

"…the teaching helps a lot to fill out the gaps in my knowledge…".

Cohort 2 EU male

The common view that teaching develops knowledge which is then used to develop skills and lead to overall improvement is clear in both cohorts but it is still not clear whether this is due to cohort specific attitudes, the level of maturity of students or the different teaching styles experienced giving them more confidence in giving direct answers. There is no obvious support for hypothesis H1 which somewhat neutralises the earlier supportive output. The indications are that a positive effect on learners' desire to learn or by inference their level of self-esteem (hypothesis H4) depends upon the context of the learning.

5.3.3. Self-Esteem in Engineers

Undergraduate Cohorts

The interesting quantitative results are at the post-teaching data collections where cohort 1 female respondents gave 12 out of 15 responses (80%) with an opposite tendency compared to cohort 2 female responses i.e. where a response during Cohort 1 moved from significant to non-significant, for Cohort 2 it went in the opposite direction (see Tables A10.13a and A10.13b). There were no such changes for males so this could indicate that females are more affected by active teaching than males. These changes were explored at interview and the overall output seems to indicate confidence in obtaining resources and ability to stick to the plan are the main issues.

Team working is a factor for some respondents:

> *"… quite confident in my abilities anyway but recognising the need to work with people has affected this negatively…".*
>
> **Cohort 1 EU female**

Teamworking may be a wider issue as others also indicated some concerns with communication and skill level:

> *"…feel more confident maybe because I am getting experience…and I realise how difficult the course is…"*
>
> **Cohort 1 Chinese female**

> *"…I have changed and now feel more confident with hardware than software – this used to be the other way around. I now see things differently and can question more effectively…"*
>
> **Cohort 1 Chinese male**

The responses tend to indicate that both knowledge and skills have been useful in positively affecting the level of confidence. For cohort 2 we see very similar responses from all those interviewed:

> *"…I have always felt confident but maybe Uni life has improved my confidence and made me feel more able to get what I need, generate solutions and stick to my plans…"*
>
> **Cohort 2 EU female**

> *"…I certainly have more confidence to get resources, stay calm, generate solutions and stick to my plans. I do use more planning now than I used to and have an active use of time to cope with stress...".*
>
> **Cohort 2 Chinese female**

Looking at male responses from cohort 2 shows a rise in confidence with some interesting observations indicating a greater willingness to enter into debate:

"…more confident in my ability to achieve my aims, get resources, stay calm, stick to plans and document things but feel these will improve more with practice. Discussion has improved (within the module) but also due to friendship groups …"

Cohort 2 EU male

"…a slight rise in relying on my own abilities but no big changes. May be due to maturity level for me but procrastination is a major problem – nothing so far has helped me get around this."

Cohort 2 UK male

Later in a side conversation the same UK male shared his view regarding continuous assessment fatigue for students who go through primary, secondary and then higher education without a break:

"Asking questions in lectures has inspired my ability to investigate but I feel the passion for education is lower in younger people, maybe due to learner fatigue …"

Cohort 2 UK male

.

There is a general indication that the passively taught cohort 1 are able to question more effectively but with no evidence of significant change in their self-esteem whereas the actively taught cohort 2 indicate more confidence in their ability to plan, ask questions, get what they need and cope with their learning more effectively. The above lends partial support for hypotheses H1 and H4.

Postgraduate Cohorts

A higher percentage of respondents from cohort 1 claim to already have a masters degree before attending this course of study (20% vs 7.5% in cohort 2) and this could affect their confidence levels positively.

For cohort 1 there were some quantitative differences noted in female responses pre to post teaching showing lower confidence in relying on oneself or staying calm under stress despite all mean scores rising slightly (Table 4.25). For cohort 2 there were no differences noted, students remained relatively unconfident in all items. This quantitative result was not evident in interviews and could indicate a lack of understanding of the questionnaire. There were also differences between gender responses (Tables 4.26 and 4.52) which indicate males and females may react differently to active teaching. However, there is a general feeling that the passively taught cohort are able to use knowledge more effectively but still have not changed much tending to dispute the earlier finding from undergraduate groups:

> *"…I am nervous about the future but know what to expect. I am more confident in theory and generally but not in planning…"*
>
> **Cohort 1 Chinese female**

> *"…I am quite confident now in my abilities…"*
>
> **Cohort 1 EU female**

> *"…I always listen to others before saying my own thoughts. I now know this is important, especially in group work…"*
>
> **Cohort 1 EU male**

This supports the view that knowledge and experience (level of skill) are being employed to improve confidence.

In the actively taught cohort there is evidence that they are more able to plan, ask questions, do things and cope with their learning more effectively:

> *"…I have more confidence to rely on myself as I stay longer in the UK..."*
>
> **Cohort 2 Chinese female**

> *"…I feel more confident in my ability to manage my time and balance conflicting requirements …".*
>
> **Cohort 2 EU female**

> *"…more confident in my flexibility to plan and this has improved my ability to manage my time. Collaborative working is useful…"*
>
> **Cohort 2 EU male**

> *"…more confident to ask questions in lectures…"*
>
> **Cohort 2 Chinese male**

> *"…perhaps practice is the key, better use of case studies and examples helps…".*
>
> **Cohort 2 Mexican male**

All of which lend some support for hypothesis H4 in this change to respondents' belief in their own abilities but it is relatively weak evidence.

When looking at significant results within each cohort (Tables 4.36 and 4.38), we see that cohort 1 experienced a rise in their confidence levels in most items whereas cohort 2 saw only one item affected indicating a difference between the groups but not necessarily due to the teaching style.

5.3.4. Self-Efficacy in Engineers

Undergraduate Cohorts

Regarding self-efficacy, quantitative data indicates males show no differences between cohorts but again, the interesting results are for females. Cohort 1 females show a varied level of confidence post teaching with some items higher and some lower but no further evidence was uncovered during interview:

> *"…I recognise the need to rely more on my own abilities than I used to do…"*
>
> **Cohort 1 EU female**

> *"…I am a little more confident about the future having learned a lot more about the topics and now I can see where I need to be – turning plans into reality…".*
>
> **Cohort 1 Chinese female**

For cohort 2 there is a very different profile for female respondents, five items started with low confidence pre-teaching but post teaching ten items showed lower confidence. This could indicate a recognition that they need to be more realistic in their expectations and take on more responsibility for their learning:

> *"…sometimes I can do things in labs that I couldn't so there are changes in me to take responsibility for my learning but most of the other students do not…"*
>
> **Cohort 2 EU female**

> *"…really changed from a team perspective and reflects the view that we are not all the same but that I have changed...".* **Cohort 2 Chinese female**

Male responses from cohort 1 repeat the need for better planning:

"…I tend to look forward and make decisions on my study but I have changed and now recognise the need for better planning for assessments…"

Cohort 1 Chinese male

but also acknowledge a personal commitment:

"…I know that I need to take more responsibility for my own learning as lectures do not cover everything…"

Cohort 1 EU male

Cohort 2 male responses are similar to cohort 1 in that they raise interesting points. For example, one student was:

"…more realistic in recognising my own shortcomings. This module will help raise my confidence to achieve even more …"

Cohort 2 EU male

"…no real changes, one needs to see what it is like to fail before one gets truly motivated…"

Cohort 2 UK male

Both cohorts picked up on the need for more individual responsibility, especially the females but males also show a more realistic expectation of their capabilities and that taking a more responsible approach to their own learning might help. The above very pragmatic view about failure being a true motivator is from one of the more mature students and tends to reflect life skills/experience rather than study skills. Overall this lends support for hypothesis H5.

Postgraduate Cohorts

There is an overall tendency for active teaching to result in a lowering of self-efficacy and this is evident more in males than females where quantitative analyses indicated that males grew less confident in more items than females for cohort 2. Age related responses indicate that older respondents are more affected than others but that overall, males and females grew more aligned in their responses after teaching interventions in both cohorts. Cohort 1 picked up on planning as an improved skill:

"…I have developed the ability to approach new tasks through further research, planning and preparation…I have just started doing this and already recognise its value…"

Cohort 1 EU male

Cohort 2 felt that they were more reliant on themselves:

"…more realistic in my aspirations and more reliant on myself but my aims have risen due to marks giving me encouragement.…"

Cohort 2 EU female

where her classmate was also:

"…more realistic in my aspirations – the course is a lot harder than I thought. Work smart - the teaching has given me the confidence.…".

Cohort 2 EU male

Overall self-efficacy has risen for those previously exposed to active teaching where leadership is concerned but not for process-based disciplines where the opposite is evident for those previously exposed to passive teaching. This is evidenced by a comment from cohort 1:

"…teaching has helped guide group working as decisions are made more easily…this is based on my past experience and I am now more reliant on myself that I can achieve at a high level…"

Cohort 1 EU female

This comment was echoed by both Chinese and Mexican males from cohort 2 who both had very similar views:

"…more realistic in what I want – the course is harder than I expected… but the teaching has given me more confidence…".

Cohort 2 Chinese/Mexican males

This shows that both teaching styles employed had similar effects but there were more positive comments from cohort 2 – Chinese females indicated they had:

"…really changed, aims have risen – the course is harder than I thought it would be but more reliant on myself...masters is hard and now realise what I might achieve. Marks have helped me to believe more in myself…".

Cohort 2 Chinese females

All of the above indicate good support for hypothesis H5 in that active teaching has a positive effect on a learner's self-efficacy in taking responsibility for their own learning but once again it seems to rely somewhat on the context of the learner's previous experience.

5.3.5. Learning/teaching style

Undergraduate Cohorts

There was a slight shift towards a more kinaesthetic learning preference in cohort 1 but no real indications of any shift of learning preference in cohort 2. At the interview, students were asked for their general thoughts on the teaching style they had received and how that may have affected the way they learn. The responses indicate that students prefer a more active teaching style:

> *"…I prefer some of the other lectures where they have interactive Q&A to do or gapped handouts…".*
>
> **Cohort 1 EU female**

> *"…I prefer to do things like filling in gapped handouts or quiz style lessons…".*
>
> **Cohort 1 Chinese female**

> *"…straight lectures are OK as I am used to them but the chance to do things in lectures as well is better…"*
>
> **Cohort 1 EU male**

> *"…lectures are beneficial overall but would like more of the style where we all have to respond rather than one or two people offering an opinion…".*
>
> **Cohort 1 Chinese male**

Cohort 2 indicated they were more used to active style teaching in their responses but were aware of context too:

> *"…active works in the right context e.g. it would not be always correct in say a Maths module...".*
>
> **Cohort 2 Chinese female**

"…active is good, liked discussions but need more info up front on the project…check the pre-uni syllabus for commonality to avoid repetition and do some elements of the project in class beforehand…"

Cohort 1 EU male

Students seemed to feel that learning has to be applied in the correct context – i.e. where being engaged in an activity or producing something rather than just listening is the best way to learn. This is an interesting view from students because it is the teacher who decides the best teaching approach and the teacher is probably persuaded more by their own level of comfort with the chosen approach rather than its effectiveness. This was not apparent from responses in the quantitative research where an active teaching approach was used. Response from a student in cohort 1 introduced the concept of active teaching removing the fear factor:

"…I like being involved and active teaching works for all students. Many will switch off if pure lecture based and use their social media group chat instead. There is a general fear of trick questions where our ability to give the correct answer is unlikely…interaction is good, especially when there is no penalty for answering…".

Cohort 1 EU female

Responses to learning style indicated some differences from pre to post teaching and this might show an underlying change was present. Indeed, it is evident from Section 4.3.2 that female students may be affected more by an active teaching approach than males. Some female respondent's views were opposite for cohort 2 compared to those from cohort 1. Interestingly therefore, there is an indication that students will make up their own minds about how they learn, in particular female students may be more willing to adapt their learning style, regardless of the teaching style they are exposed to. The above lends partial support for hypotheses H1, H2 and H4.

Postgraduate Cohorts

From quantitative analysis overall shifts in preferred learning style were minimal in both cohorts, a tendency towards visual learning is suggested. However, there was a slight shift towards a more kinaesthetic learning preference in 24-35 year old respondents from both cohorts but no other indications. Contrary to the quantitative evidence, interview responses from cohort 1 indicated there were changes in the way they learn. An EU female said:

"…my learning style has developed through the course quite a lot…I have learned how to better approach prep and assignments…"

Cohort 1 EU female

"…big change for me in the way I learn from a formulaic method to thinking more about what I want to do, making my own decisions…".

Cohort 1 Chinese female

"…I do more reading rather than cram for exams. Teaching has opened my eyes to rely more on my own desire to learn through more research-based info gathering…".

Cohort 1 EU male

Students from cohort 2 where active teaching was employed seem better motivated to prepare for lessons:

"…asking questions and discussing in class is good. I have gone back to making check lists to ensure I am ready for the next class.…"

Cohort 2 EU female

"…I now read more before coming to class – adapted & better preparation... I have learned to not expect spoon feeding and do more preparation…".

Cohort 2 Chinese female

Male respondents from cohort 2 all indicate a level of comfort with active teaching in the way it affects their learning:

"…I gain more confidence to speak up and feel safer, not lose face if I am wrong…"

Cohort 2 Chinese male

"… I have increased belief & trust by being able to ask for further guidance and confirm understanding…"

Cohort 2 Mexican male

"…asking questions and discussing in class is good. Interaction with tutors allows more learning, more productive/effective.…".

Cohort 2 EU male

The responses indicate that passively taught students have a tendency towards improved decision making and self-reliance whereas actively taught students have an improved reliance of themselves to plan, ask questions and clarify things. There is no obvious support for changes to learning preference through the teaching approach but this does lend some measure of support to hypothesis H2 that active teaching has an effect on a student's preferred learning style.

5.3.6. Thinking style

Undergraduate Cohorts

There was a slight shift towards a more reflective approach in both cohorts and whilst this was very slight using overall cohort averages, some individuals within each cohort did indicate some significant changes (see Section 4.3.3). Gender-based responses indicated that both males and females who were exposed to active teaching (cohort 2) seem to have become more reflective and more willing to experiment which is the same for males from cohort 1 but opposite to females from cohort 1:

> *"…found I was thinking more about the lesson than I used to…"*
>
> **Cohort 1 EU male**

> *"…I practice questions more now and tend to keep more notes but generally this study is helping me to improve…"*. **Cohort 2 EU male**

> *"…not really changed but I seem to want to study more…"*
>
> **Cohort 1 Chinese female**

> *"…learning was only kinaesthetic but has changed … through available university resources. I now use a mix of reading, note taking and experimentation…"*.
>
> **Cohort 2 Chinese female**

Summarising all responses shows a shift towards a more mature way of thinking overall, in both cohorts, but in small cohorts the evidence is indicative only and this aspect would benefit from further research:

> *"…I have changed and now use a study plan which is something I would not have done before this course…"*
>
> **Cohort 2 Chinese male**

“…I knew my learning style was different because I used my spare time more constructively but I could not put a label on it…”.

Cohort 2 UK male

However, one male respondent in cohort 2 observed (after the interview had concluded) that whilst some people do reflect more now (on their learning):

“…if there is currently a balanced response to thinking styles, deliberately moving that balance to one that is more polarised through use of a different teaching approach might not be desirable for the student or beneficial to achievement of the learning outcomes...”.

Cohort 2 UK male

This seems to be a very astute observation and was only captured by chance.

It is useful to see that whilst no overall major changes are detected, the results pre to post teaching for cohort 2 are similar to those for cohort 1 in overall change patterns. No obvious changes in thinking style are indicated through the use of an active, flipped classroom, teaching style.

Considering that active teaching does encourage ideation, option generation and discussion, and that passive teaching encourages listening and taking on board knowledge through lecture, these small changes may be indicative of a shift in overall cohort thinking based on teaching style and is thus something that would be interesting to look into for engineering students in the future. However, there is little evidence here that would support hypothesis H3.

Postgraduate Cohorts

There was a slight shift away from a reflective approach in both cohorts and whilst this was very slight using overall cohort averages, individuals within each cohort did indicate some significant changes (see Section 4.3.3). Summarising interview responses shows a shift towards more use of thinking to plan in both cohorts. Two females in cohort 2 made separate but similar observations:

"…more reflective in general but I also recognise the need to read more carefully as well…" and *"…more reflective in general but I also recognise the need to read more now... "*.

Cohort 2 Chinese females

Interestingly, all respondents in both cohorts indicated they were more reflective but this was not shown to be the case for the group overall. One possibility is that those individuals interviewed were in the minority. However, since the interviewees were selected randomly it is an odd result. Alternatively, it could be that the instrument is not accurately discriminating between different thinking styles. Students from cohort one felt that their passive teaching experience had been OK but they would have liked to have been more involved in the lessons:

"…I would be more happy to do in lesson discussions now rather than straight lecturing. I would prefer to get theory to read and then do case study discussion in class for clarification...".

Cohort 1 UK female

"…I am used to straight lectures but I can see where more discussion and creativity could be useful…"

Cohort 1 UK male

This tended to support active rather than passive teaching but interestingly it did not exclude passive teaching per se. Cohort 2 respondents indicated that active teaching through case studies was the key needed to promote discussion. This is interesting too in that the two elements of case study and discussion were linked to the teaching style rather than students seeing the teacher as the facilitator to promote active learning. Cohort 2 respondents felt that:

"…active teaching works for students in different ways – depending on their cultural background…"

Cohort 2 UK female

"…having the assignment structure and active discussion around the topic helped in research activities…"

Cohort 2 UK male

The above tends to indicate that males were focussed more on doing what was needed to get a good pass but that females recognised the need for depth of understanding in order to achieve a good result. Similarly, to undergraduate cohorts, results for postgraduate cohort 2 reflect those for cohort 1 in overall change patterns thus no obvious changes in thinking style are indicated through the use of an active, flipped classroom, teaching style and there is no support for hypothesis H3.

5.4 Non-Parametric tests for statistical differences

Undergraduate Cohorts

Wilcoxon signed rank tests for cohort 1 show significant changes in the 'importance of knowledge' and the importance of being creative (skill) that are not repeated for cohort 2. However, in the 'self-esteem' and 'self-efficacy' categories cohort 1 students showed no significant changes but cohort 2 students did. These differences could be a result of a changed teaching style but there is little hard evidence to support this. No other items show any significant changes overall.

For skills, the students' perception of their importance for engineers is less volatile than it was for the 'importance of knowledge'. This is interesting as female students in both cohorts indicated they would be more able to assess skills than engineering knowledge whereas male students in both cohorts felt the opposite.

For self-efficacy, gender differences for cohort 1 changed for the item 'concentrate on technical engineering subjects' from significantly different to non-significantly different, in fact they tend towards a much more closely aligned response between genders where female average score rose from 2.875 to 4.000 but males only rose from 3.760 to 3.923. Engineering in general tends to be a male dominated discipline, and in this cohort, we see a similar pattern with around 25% of respondents being female in both data collections. The item may have felt more daunting to females pre-teaching but with a short period of experience in the discipline they may be more confident of their ability to cope with technical aspects. No such effect was seen for cohort 2 thus cohort differences may be in play here but there could also be an indication that active teaching has had a lesser effect on student confidence levels than passive teaching.

Learning style indicates a shift towards greater listening and analysis in students exposed to an active teaching style compared with those exposed to a passive style. No firm conclusions can be drawn with just two cohorts of undergraduate students but it is something to consider when designing the teaching for particular engineering courses.

Using the Mann-Whitney U hypothesis test for significant differences in the distribution of data between genders and between experience of teaching styles there are no differences from first to second data collections between genders for the 'importance of knowledge', 'importance of skills' or 'self-esteem' categories. Some self-efficacy categories did change for cohort 1 but not for cohort 2 indicating that active teaching may not actually affect self-efficacy after all. This is supported by Mann-Whitney U tests carried out for differences across styles of teaching that found no significant changes at either data collection.

Postgraduate Cohorts

The Wilcoxon signed rank tests for cohort 2 show only three items with significant changes across all categories whereas cohort 1 showed some 21 items so there is some evidence that cohort 2 exhibit more stability when exposed to an active, discursive teaching approach compared to a passive approach. Paired sample tests for the same three items returned the same significance results supporting the initial statistic.

For self-efficacy, the larger effect change in the item 'taking class notes' for cohort 2 when compared to the same for cohort 1 (Tables 4.76 to 4.79) might reflect the constant exposure to discussion and project planning activities making respondents more comfortable with this.

Learning style indicates there are no main changes, respondents seem to have retained their basic preferences for learning in both cohorts. Tests of normality for learning preference against age (Table 4.43) values are less pronounced in cohort 2 (although statistically significant). These probably reflect a more mature attitude to helping others (teaching) and decision making (choice) alongside a pragmatic view that what you say (conversation) and how you get the most from learning (concentration) are perceived as being rather more important than was expected when the course started.

Using the Mann-Whitney U hypothesis test for significant differences in the distribution of data between genders there are no differences from first to second data collections for the importance of knowledge or the importance of skills. Amongst the self-esteem category, items 'resourcefulness' and sticking to my plans' show an improved confidence for cohort 1 and the item for 'achieving aims/goals' is significantly different between genders for cohort 2 but there is no further support for these findings using means. The self-efficacy items for 'taking part in discussions', 'designing experiments' and 'documenting technical procedures' that show significant gender differences for cohort 2 indicate that males grew less confident whilst females remain or grew in confidence (Table 4.26).

Looking at teaching style differences for cohort 2 the knowledge of 'design and production' and skill in 'design and production of products/services' show more confident responses. These may be supported by the self-esteem measure for 'getting resources' gaining in significance but coping with uncertainty becoming less significant. These are further supported by self-efficacy measures showing the ability to finish things on time and to write clear and concise plans becoming more significant to respondents. When active and passive approaches are investigated a mixed result indicates active teaching instils more confidence in leadership aspects but reduces confidence of ability in other items. This is an interesting result as it tends to indicate active teaching raises many more questions in students than a passive approach.

5.5 Overall thoughts and Conclusions

Undergraduate cohorts

The above conclusions show the combined effect on two undergraduate cohorts and do not show any strong supporting evidence regarding different teaching approaches being more or less effective. Some support has been indicated for hypotheses H2 where a more kinaesthetic learning style is indicated, H4 and H5 where respondents indicate a higher level of confidence now and going forward, a mixed level of support for hypothesis H1 that tends towards rejection rather than support but no evidence in support of hypothesis H3 on learning style impact. However, one needs to bear in mind that the cohorts, whilst similar in construction, were different individuals and may have reacted differently had they been exposed to another style of teaching approach given that the teaching style changed in only the one module. The gender differences, especially in learning style preference, are worthy of further investigation at a later date and could be the basis of further PhD research.

The size of cohorts was not originally thought to be a factor in collecting data, indeed it was chosen specifically to test the effect of a flipped classroom approach on larger groups of students. In this aim it was successful but the initial data collection exercise was not handled well by the researcher and resulted in fewer responses than was anticipated.

The research method evolved slightly as time elapsed, to include other items of data such as the respondent's previous experience of teaching style and their ethnicity plus the method of data collection was improved to encourage more student responses and possibly improve the effectiveness of the research.

Postgraduate Cohorts

When considering results for both cohorts of postgraduate students, respondents for both styles of teaching report that the need for knowledge in engineers gains in importance over the taught period with some indication that active teaching may have more impact than passive teaching. Overall support for the research hypotheses match those of the undergraduate cohorts quite closely.

Male and female responses indicate that males consider knowledge easier to assess than skills whereas females have an opposite view. Most average scores for males have risen for cohort 1 but some for females have dropped leading to combined changes. These changes have resulted in little change overall but there are some statistically significant differences that may be attributable to a passive teaching style.

The overall conclusion for the age-related analyses is that 25-34 year olds in cohort 1, with more experience and more mature attitudes, seem more cautious after the teaching about what it is possible to achieve than their younger colleagues. Whereas those older respondents in cohort 2 are more likely to be objective when assessing their skills, current and future capabilities and their learning styles. Cohort 2 has a slightly higher percentage of respondents but this is likely to be noise in the data rather than some significant finding.

Planning is seen as a key skill but there is a need for knowledge about planning and some skill in creating the overall plan thus knowledge and skills are linked.

Passive teaching fosters the use of knowledge where active teaching fosters planning, questioning and the ability to cope with learning. This supports one aim of active teaching, creating more curiosity.

There are no obvious changes in thinking style through the use of active teaching but there is some indication that active teaching has more of an effect in female students.

Chapter 6 will synthesise undergraduate and postgraduate cohort differences and point towards further research opportunities.

6. Discussion and synthesis of findings

6.1 Introduction

This chapter brings together the output from both undergraduate and postgraduate cohorts comparing them by data category and the use of a passive (cohort 1) or an active (cohort 2) teaching approach. After this brief introduction, Section 6.2 sets the context of the research in terms of respondents, methodology and location of supporting information. Section 6.3 is subdivided to present main findings by category where Section 6.3.1 gives an overview of scale consistency for reliability, Section 6.3.2 discusses the Importance of Knowledge, Section 6.3.3 the Importance of Skills, Section 6.3.4 the Opportunity to Improve, Section 6.3.5 Self-Esteem and Section 6.3.6 Self-Efficacy. Section 6.3.7 looks at Learning/Teaching style, Section 6.3.8 considers Thinking style then and Section 6.3.9 the main statistical test outputs for validity. Finally, Section 6.4 pulls together overall findings.

Throughout this research, there was an indication that gender may have affected the results more than expected. Identified differences in gender responses were examined for undergraduate versus postgraduate responses, taking into account differences in the age of respondents and their experiences of a passive/active teaching style prior to these data collections.

Ethnicity may also have had an impact but after testing, there are no differences whatsoever shown by respondents from different ethnic backgrounds, confirming the thinking on this aspect from Section 1.2.5, and so this aspect will not be discussed further.

6.2 Context

As a final reminder of the overall context of the research reported here it is useful to remember that the undergraduate cohorts, comprised of year 1 students new to HE, were asked to respond prior to and after experiencing teaching on a project module that was designed to improve team working, creativity and project planning/management. This included the development of leadership and communications skills in order to foster a more inclusive working relationship and culminate in the practical realisation of a product or service the team had created from initial idea through to prototype. The pre and post teaching questionnaires gathered quantitative data, most of which is reported in Appendix 10, and were followed up through interviews to gather qualitative data where statistical anomalies or indications were identified as needing further investigation (see Appendix 11). Cohort 1 was exposed to a passive teaching style and considered to be the control group where cohort 2 were exposed to an active teaching style using a flipped classroom approach. Results from both cohorts were compared to identify any impact due to the use of the flipped classroom in a normal HE lecture situation i.e. groups of 50 or more students.

The postgraduate cohorts were comprised of international students on a one-year MSc course and were experiencing UK HE teaching for the first time (true for circa 98% of respondents). The methodology employed was identical to that utilised for the undergraduate students but was introduced during a project planning module designed to improve their ability to assess, clarify and analyse data and then construct a viable project plan.

Quantitative and qualitative data have been discussed in chapters 4 and 5, this chapter will summarise and synthesise the main findings, leading to the final conclusions set out in Chapter 7.

6.3 Main findings

Both undergraduate and postgraduate cohorts displayed similar pre-teaching respondent profiles in terms of number of respondents, gender split, age profiles and ethnicity. This gave the researcher confidence in pre/post-test comparisons between cohorts and that any differences in post teaching results between respective undergraduate and postgraduate cohorts might be due to the teaching style adopted.

6.3.1 Internal consistency

The undergraduate scale consistency is good for nearly all categories in both cohorts. One poor result pre-teaching for the self-efficacy category was traced back to an outlier which, when removed, restored consistency to that category. Undergraduate cohort 2 may show more willingness to question effectively, analyse and respond accordingly thus adding more clarity to their understanding as all respondents agreed that:

> *"…asking questions and discussion in class is good…".*
>
> **Both cohorts all respondents**

This shows additional support for the use of an active teaching approach in engineering teaching generally as well as its effectiveness in larger cohorts (Bishop and Verleger, 2013; Gullayanon, 2014; O'Flaherty and Phillips, 2015; Reidsema et al, 2017; Lombardini et al, 2018).

The postgraduate scale consistency is also good except for one post teaching result for the 'importance of knowledge' category. Possibly the active teaching approach has introduced doubts in respondents regarding the importance of knowledge for engineers but looking at means that are very similar there is nothing to indicate why the scale indicates poor consistency post teaching – this was not anticipated:

"…I have always considered knowledge in the broadest sense to be important, my views have not changed…"

Cohort 2 EU female

"…not really changed at all, I would single out the marketing one (item) if asked but have always felt all of them to be important…"

Cohort 2 EU male

Looking at some of the skills the students need to master e.g. creativity and team working, it was expected that with a more active teaching style, cohort 2 would show more creativity and be more willing to discuss issues or problems. This has not been evident but there has been some indication that females exposed to active teaching are more willing to question aspects of learning e.g from an EU undergraduate in cohort 2 saying that she had:

"…not really changed but (it is) easier to assess skills…".

Cohort 2 EU Undergraduate

The above is worthy of note for future investigation.

The self-esteem category showed for undergraduates that planning and confidence in their current abilities had risen. There were no major changes for postgraduates, possibly indicating their more mature status and previous experiences of teaching at HE level.

Of interest in the undergraduate self-efficacy category is one item 'finish reports and assignments on time' that showed a reduced confidence for both cohorts but the result for cohort 2 was statistically significant. Two UK males both felt they were:

"…more realistic in my aspirations…"

Cohort 2 UK males

However, one went on to say:

> *"…the course is a lot slower than I thought it would be but the reading helps in my drive for learning…"*.
>
> **Cohort 2 UK male**

Of course, this might simply indicate he preferred a visual rather than an active style of learning. Quantitative checks for gender differences did not reveal anything other than a more even distribution of responses post compared to pre-teaching.

Postgraduate responses showed statistically significant differences between genders pre-teaching that moved to non-significant values post teaching tending to indicate that exposure to debate and discussion on a regular basis has led to an improvement in the student's ability to reason and a greater balance between genders overall:

> *"…I am clear that I need to do my own research outside of lessons. Case studies are a very good thing to help clarify the reading and private study materials…"*.
>
> **Cohort 2 Chinese female**

Another item for 'planning and organisation' also moved strongly away from significance, giving some weight to the assertion that active teaching may positively affect these skill areas (Everett et al, 2014).

6.3.2 Importance of knowledge

In the undergraduate cohorts, the item 'knowledge of design and production' saw drops in mean values for both cohorts indicating that both active and passive teaching approaches have had some negative impact for this item. It was expected that the active teaching approach would have resulted in a more positive impact given that the investigative nature of taking on new knowledge was emphasised more and encouraged through the teaching materials:

> *"…nothing (had changed) other than what I would expect by being given new knowledge…"*
>
> **Cohort 2 Chinese male**
>
> *"…no changes…".*
>
> **Cohort 2 UK male**

The opposite is seen for postgraduate cohorts where means rose in both cohorts. Indeed, there is a general indication that postgraduate students are happier with their knowledge but less able to assess their need for skills than their need for engineering knowledge. One respondent felt that the importance of knowledge was:

> *"…more enhanced but not especially (so)…".*
>
> **Cohort 1 EU male**

This is opposite to undergraduate indications and probably reflects the experience of postgraduate cohorts and their general development of a more mature view of the time and effort needed for skills development.

There is a tendency for all postgraduate respondents to see knowledge as more important than they did at the start of their studies with a slightly higher perception of this from cohort 2 where active teaching was used. As discussed above, this may further reflect the postgraduate levels of previous experience but is not enough to indicate a definite change being attributable to the teaching approach.

Gender differences in this category are confined to female respondents who exhibit differences for some items at post teaching data collections in all undergraduate and postgraduate cohorts whereas males remain the same at all times. This finding was more obvious in postgraduate cohort 2 interview responses where the overall importance of knowledge was identified rather than specific items within the category:

> *"…knowledge theory is very important…"*
>
> **Cohort 2 Chinese female**

> *"…need for knowledge is more than I thought it would be…".*
>
> **Cohort 2 EU male**

This significant finding could be an indication of a possible effect through the use of an active teaching approach and is an area for future research. Gender responses for both undergraduate and postgraduate respondents indicate that males consider knowledge easier to assess than skills whereas females have an opposite view.

There were indications that older, more mature respondents, were less comfortable with items of accounting and quality yet more comfortable with project planning and dealing with people.

6.3.3 Importance of skills

Cohort 1 undergraduates show a different response to cohort 2 in that cohort 2 responses are generally less clustered with more responses in the extremes. This may be due to proportionately more responses being collected at the start of research with cohort 2 than for cohort 1 (the data collection methodology was altered as explained in Section 3.3) or that the teaching style has caused this effect. No other external effects or internal changes were identified as potentially causing this difference between undergraduate cohort responses. For postgraduate respondents in general there were some indications of change for cohort 1 but none for cohort 2 which might indicate an impact through active teaching. This was an odd result but might be linked to the students' general opinion on the development of skills when compared to the acquisition of knowledge (see Section 6.3.2) as one respondent from cohort 2 felt the importance of skills to be:

> *"…maybe still the same but all (skills) should exist to a certain extent. Too subjective to say…".*
>
> **Cohort 2 EU male**

Gender responses for undergraduates in this category show a lack of changes for male respondents but a significant change for female respondents for the 'give effective presentations' item in cohort 1 that was not seen in cohort 2. Indications are that passive teaching introduced doubts in this item whereas active teaching could not reduce doubts already held. Another interesting finding is that the item 'using discussion effectively' has reduced in significance for both undergraduate cohorts by almost the same amount. This could mean that the overall level of comfort that students have with asking questions and discussing issues after 3 months of teaching across their course of study has risen despite the style of teaching adopted. Undergraduate cohort 1 female respondents also became less concerned about producing quality reports or using discussion to investigate an issue. In undergraduate cohort 2 female respondents became less concerned with creativity, formulating good questions and again using discussion to investigate an issue. This is interesting as it points towards an active teaching approach being more effective in stimulating curiosity and willingness to question in females studying engineering. No comparable male differences were identified. For postgraduate cohorts there are no significant differences in general but there is a common feeling that females find skills easier to assess than knowledge where males feel the opposite to be true. This is reflected by undergraduate responses as well and could point to males being more in favour of traditional written exams than females which contradicts other research that found no differences between genders and their preferred mode of assessment (Woodfield et al, 2005; Furnham et al, 2011).

Comparing responses by age gave indications that older respondents in the postgraduate cohorts became less comfortable with items of quality, communication (oral and written) and design yet more comfortable with solving problems. Undergraduates also indicated that maturity and previous experience of learning new skills was a factor to take into account, especially when putting together teams for the module:

> *"…not enough up-front experience of problem solving so more guidance/info here would be good…for year 2 preparation…".*
>
> **Cohort 1 EU female**

Given that team-working is part of the module and that active teaching has placed more responsibility on the individual to prepare for lessons, this combination of factors has introduced more pressure on their available time an effect also noticed by Lombardini et al (2018). This may have led to less time available to experience practical team-working in undergraduate cohort 2 compared to cohort 1. Indeed, introducing a requirement for a higher level of self-efficacy through active teaching may have had more impact on cohort 2 than was expected and might be an unintended result of active teaching supporting findings by Abeysekera and Dawson (2015).

6.3.4 Opportunity for Improvement

There was a clear similarity of opinion in both undergraduate and postgraduate respondents when discussing the importance of having an opportunity to improve. Both indicated that planning was a key skill to develop but that in order to do so one needed more knowledge thus the two categories (importance of knowledge and importance of skills) were intrinsically linked:

> *"…I think one relies on the other so both have improved…"*.
>
> **Cohort 2 Chinese male**

The short responses from cohort 2 interviewees in both undergraduate and postgraduate cohorts reflected the ability to give direct answers whereas cohort 1 interviewees seemed to want to explain what had improved rather than offer a direct opinion (see Appendix 11). It is not clear whether this is due to cohort specific attitudes, the level of maturity of students or the different teaching styles experienced giving cohort 2 more confidence in giving direct answers but this is a key finding to be further explored in future research.

6.3.5 Self-esteem

For undergraduate cohorts, self-esteem measures indicate that gender differences appear to be a common factor for all respondent groups. Male respondents show no differences between cohorts:

> *"…I don't really have an opinion on this…"*
>
> **Cohort 1 EU male**

Whereas females show a high percentage of cohort 1 responses (86.7%) to be opposite to cohort 2 responses. This could indicate that females are more affected by active teaching than males – a key finding.

Cohort 1 responses for females indicated reduced confidence in relying on oneself or staying calm under stress. However, responses for females in cohort 2 showed no differences, students remained relatively unconfident in all items. This quantitative result was not evident in interviews and could indicate a problem with the research instrument where respondents lacked understanding of the questionnaire items in this category:

> *"…inspired to improve my ability to investigate…"* and *"…my research skills are improving and I rely on myself more…"*
>
> **Cohort 2 Chinese/UK males**

This indicates an opposite stance to quantitative results. It raises questions regarding the use of different cohorts and whether a methodology that avoids changes of respondents would be better for this type of research.

Postgraduate cohort 2 shows no clear indication that belief in their current capabilities has changed which is slightly surprising:

> *"…I have certainly more confidence to rely on myself…"*
>
> **Cohort 2 Chinese female**

> *"…changed my approach to lectures and assignments…"*.
>
> **Cohort 2 UK male**

However, there is a general indication that passive teaching enables a more effective use of knowledge and the need to ask questions whereas active teaching enables better planning, organising, questioning and responsibility in learners. This is seen for both undergraduate and postgraduate respondents and is potentially a key finding.

The passive teaching style adopted for cohort 1 postgraduate students was associated with a few changed responses for self-esteem in students who had already experienced a passive teaching style. This is interesting in that those who had experienced an active style previously were almost unaffected. This is slightly surprising and not reflected in cohort 2.

6.3.6 Self-efficacy

A common factor picked up on by both undergraduate and postgraduate respondents is the need for taking more responsibility for their own learning through greater planning. This is an important point and provides support for an active teaching approach identified in the self-esteem category as having a positive impact on the ability to plan. Some items did change for postgraduate cohort 2 indicating that active teaching may not actually affect self-efficacy positively after all! Cohort 1 paired sample tests for self-efficacy showed seven items with statistically significant results, three of which involve planning (Table 4.77), where cohort 2 had only one item (Table 4.79) that tends to support the self-reliance discussed above. This is interesting given that cohort 2 contained fewer people having already achieved a masters level qualification. Indeed, the item for 'take useful class notes' shows a large decrease indicating the cohort as a whole has less confidence in their ability to do this (Lombardini et al, 2018). This could also reflect that they have experienced lots of active lectures, notes are given up-front for them to read and discuss thus lessening their willingness to capture key points during the class – an unintended effect and thus a slightly surprising result. The above tends to be backed up by the same

Mann-Whitney U tests being carried out for differences across styles of previously experienced teaching that found no significant changes at either data collection.
Most of the differences in this category for undergraduate cohorts were traced back to gender responses where males show no differences between cohorts but females in cohort 1 show one item ('taking class notes') with reduced confidence but another ('document technical procedures') where they grew more confident. For cohort 2, after experiencing an active teaching approach, there is a very different profile for female respondents. Five items started with low confidence pre-teaching but post teaching ten items showed lower confidence indicating a recognition to be more realistic in their expectations and take on more responsibility for their learning. The postgraduate cohorts were less volatile overall with only one difference between genders in cohort 1. Again, males showed no changes for any items but females indicated a lower confidence in leadership capabilities – cohort 2 postgraduates showed no changes for either gender.

6.3.7 Learning/Teaching Style

Undergraduate and postgraduate cohort 1 showed a slight shift towards a more kinaesthetic learning style preference. Postgraduate cohort 2 showed a very slight shift towards a more visual learning style preference whilst undergraduate cohort 2 did not show any shift in learning style preference but interview responses indicated that whilst active teaching might be preferred, rather than use it all the time, it has to be used where appropriate (Nwokeji and Holmes, 2017) – a Chinese female stating:

> *"…active (teaching) works in the right context…".*
>
> **Cohort 2 Chinese female**

This is a key finding considering that an active teaching style was thought to have more impact on learning style preferences. The postgraduate responses indicate that passively taught students perceive themselves to be better at decision making and self-reliance where actively taught students consider themselves to have improved their questioning and clarification capabilities. This may be through improved use of language but more importantly, this could be an unintended effect of active teaching that requires students to develop their language skills. Learning style indicates a shift towards greater listening and analysis in students exposed to an active teaching style compared with those exposed to a passive style. Cultural differences may be at work through expected behaviour of students during previous learning experiences although no quantitative evidence is available to back this up. Some interview responses for postgraduate cohorts indicate a shift in learning approach by students when encouraged to do so through active teaching:

"…active gives Chinese students freedom to relax and improve…"

Cohort 2 Chinese female

"…with so few lectures, being encouraged to discuss is crucial…"

Cohort 2 UK male

"…debating, role play, defending your position feels more important…"

Cohort 2 UK male

This indicates more confidence in asking questions due to the environment within the class. No firm conclusions can be drawn but it is something to consider when designing teaching for particular engineering courses. Lesson planning should take account of learning outcomes and select the appropriate teaching approach for that specific outcome (RAE, 2007; Sheppard, 2013; Clark and Andrews, 2014; O'Flaherty and Phillips, 2015; Karabulut-Ilga et al, 2018). This would help set the context correctly for the learner and also help the teacher to best select their specific teaching approach at any point during a course of teaching.

6.3.8 Thinking Style

No major changes in thinking style patterns are indicated for either undergraduate or postgraduate cohorts through the use of an active, flipped classroom, teaching style. Postgraduate respondents showed a slight shift away from reflective thinking which is opposite to undergraduate respondents. However, some undergraduate interview responses indicate a shift to a more reflective and mature way of thinking with a Chinese female saying:

"…I think on a bigger scale, focussed on what might happen rather than what needs to be done…"

Cohort 2 Chinese female

"…more practical reflection than anything else…".

Cohort 2 UK male

Applying this to planning aspects, this supports the focus on planning seen earlier in self-esteem and self-efficacy categories. There was an interesting observation by one respondent at interview who noted that trying to change a person's way of thinking through any specific form of teaching approach may not be a) desirable or b) beneficial – to either party. This was a surprising comment but helped the researcher to reflect on the thinking style outputs more, consider the pragmatic approach of most engineering students and question the overall tenet of a preferred thinking style. These issues support some of the research on this aspect in the literature review section (Benziger, 2013) and points towards other research being needed in this area, probably on the instrument that is used to collect data as well as the overall research construct (also seen earlier in Section 6.3.5 under self-esteem).

The postgraduate responses indicated a slight shift away from a reflective approach in both cohorts and this is interesting as it is the opposite to the undergraduate responses showing differences between them. One possibility is that the instrument is not accurately discriminating between different thinking styles.

6.3.9 Non-parametric tests for statistical differences

The Wilcoxon signed rank tests for undergraduates show no major changes that could be attributed directly to the teaching style but there were some gender differences that indicate a potential for an active teaching approach to be beneficial for female students in technical and engineering content. There are also indications of a shift towards greater listening and analysis in students when exposed to active teaching as well as some greater confidence in their abilities to perform in the future – their self-efficacy.

Postgraduate cohort 1 showed far more statistically significant changes than cohort 2, indicating a more stable response from those exposed to active teaching. Paired sample tests for the same items returned the same significance results supporting the initial finding.

Using the Mann-Whitney U hypothesis test for significant differences in the distribution of data between genders indicates that postgraduate males grow less confident whilst postgraduate females remain or grow in confidence. This is different to undergraduate responses where all were more confident and may reflect the differences in background for these two sets of respondents. When active and passive approaches are investigated a mixed result indicates active teaching instils more confidence in leadership aspects but reduces confidence of ability in other items. This is an interesting result as it tends to indicate active teaching raises many more questions in postgraduate students than a passive approach. This may have some support from both UK and EU males in cohort 2 who both said:

> *"…yes, I reflect more and have improved my critical evaluation too…".*
>
> **Cohort 2 UK and EU males**

6.4 Overall findings

In all categories, differences in responses from cohort 1 and from cohort 2 are confined to female respondents whereas males remain the same at all times. This finding was more obvious in postgraduate cohort 2 but this significant finding could be an indication of a possible effect through the use of an active teaching approach and is an area for future research given the relatively low numbers involved here.

For skills development, the overall level of comfort that undergraduate students have with asking questions and discussing issues has risen in both cohorts thus it is probably not teaching style dependent. However, female respondents in cohort 2 are also more comfortable with asking questions and using discussion to investigate an issue, pointing towards an active teaching approach being more effective in stimulating curiosity in females studying engineering (Khun, 2005; Jackson and Ward, 2012). Postgraduate cohorts point to males being in favour of more traditional written exams whereas females are not. Indeed, active teaching may have had more impact than was expected in terms of confidence in their ability to perform (self-efficacy) and might be an unintended result of active teaching (Abeysekera and Dawson, 2015).

The opportunity to improve is important for all students in all cohorts but cohort 2 responses indicate more willingness to answer in a more precise and direct manner which could be a result of the use of active teaching where dialogue and informed opinion were encouraged.

Self-esteem measures indicate that passive teaching is more effective in promoting the use of knowledge whereas active teaching is more effective in promoting responsibility for their own learning in students with females being more affected by active teaching than males. These are key findings that are worthy of further investigation.

In self-efficacy measures there is evidence of both undergraduate and postgraduate students, in both cohorts, taking more responsibility for their own learning through greater awareness of the realities of acquiring knowledge and skills by using better planning. A negative effect though is that their willingness to take notes is decreased which was not expected.

Learning style responses indicated only minor shifts in learning style preference except for undergraduate cohort 2 where no shift in learning style was evident. An active teaching style was thought to have more impact on learning style preferences so this is an area for future investigation alongside the more general learning styles concept for engineering students.

Comments from an undergraduate on change to a person's way of thinking through a specific form of teaching approach led to reflection on the thinking style outputs and to question the overall tenet of a preferred thinking style. The postgraduate responses indicated a different shift in thinking than undergraduates, moving away from rather than towards a reflective approach – this was opposite to that expected and contrary to findings in other research (Kolb, 1984; Benziger and Sohn, 1993).

Consistency measures were expected to support greater creativity where an active teaching style was employed but this has not been evident. However, there has been some indication that females exposed to active teaching are more willing to question aspects of learning and this is worthy of note for future investigation, perhaps the research should use a single cohort to aid consistency and concentrate on more qualitative responses too.

Students who are exposed to an active teaching style respond with fewer statistically significant changes between first and second data collections. Looking at these findings from a gender perspective identifies a difference between postgraduate and undergraduate responses. Undergraduate males and females all indicate greater confidence but postgraduate males show the opposite – this once again may reflect that older respondents, with more experience, are more pragmatic about what they may be able to do. Active teaching has a positive impact on confidence in leadership but a negative impact elsewhere. This may point towards a greater level of curiosity being generated through an active teaching approach, particularly in postgraduate students (Binson, 2009; Jackson and Ward, 2012).

Chapter 7 presents a summary of the research set out by hypothesis, overall conclusions from the findings and next steps that might be useful for follow up research.

7. Summary, conclusions and next steps

7.1 Introduction

The research set out to identify whether a flipped classroom active teaching approach, used to good effect in general education (e.g. Bidwell, 2014; Tucker, 2012) and also in higher education (e.g. Zappe et al., 2009), was more beneficial to engineering students than a traditional didactic approach. As the researcher currently works in engineering education, the action-based research was focussed specifically in this context to inform pedagogical development in engineering education. The research reported in the preceding chapters was inspired by the researcher's curiosity as to why engineering students do or do not engage with teaching through investigating changes in student attitude and motivation to study rather than summative results after teaching interventions as most flipped classroom studies seem to consider (Karabulut-Ilgu et al, 2018). It was piloted on a smaller scale (12 students) with first year students taking an engineering management module under the label "Curiosity-based learning" (CBL) where a flipped classroom teaching style was used with micro-lectures and findings were encouraging enough to see whether this style of teaching approach would work in larger cohorts i.e. all first-year students (circa 120). The research was modified and designed from the researcher's earlier CBL study to be carried out in a HE large classroom setting i.e. more than 30 students, as at the time there was an identified lack of research into the effects of flipped classroom approaches for a) large groups and b) engineering students (Jackson and Ward, 2012; Toto and Nguyen, 2009; Zappe et al., 2009). A further review of research has identified some large engineering cohort studies into flipped classroom teaching (see Chapter 2, Section 2.3) that are included, as appropriate, within this summary chapter. The output would not only inform pedagogical development within the engineering arena but also teaching practice, providing a platform for future research.

The researcher wanted to test whether there was a noticeable change in student attitudes towards study if they were exposed to an active teaching style. In order to do this, the research adopted a two-cohort methodology where students were surveyed quantitatively before and after being taught and also qualitatively after the pre and post teaching questionnaires were analysed. This was a longitudinal study using two undergraduate cohorts and two postgraduate cohorts being taught using a passive approach with the first cohort (2016-17) followed by an active approach for the second cohort (2017-18). The passive approach adopted a standard, didactic lecture format where students listened, took notes and asked questions at the end for clarity. The active approach used a flipped classroom method (Tucker, 2012) where students had case studies to read prior to lectures and the lecture session followed an interactive, discursive style, encouraging students to interact with each other and the lecturer who acted more as a facilitator to stimulate discussion. The use of both undergraduate and postgraduate cohorts allowed the research to cater for other factors such as maturity or previous experience of teaching when analysing results.

7.2 Research Question

The research needed a better focus to allow it to complete and thus the following research questions were formulated:

1) *The flipped classroom – does this dialogic and active teaching approach lead to a change in a learner's preferred learning or thinking style compared to a didactic approach?*
2) *Does a flipped classroom approach enable students to be more confident in taking responsibility for their own learning and achievement compared to a didactic approach?*

7.2.1 Main Research Focus

The research question was split into four sub questions which asked whether an active teaching approach can 1) impact upon a learner's desire to learn, 2) their preferred thinking style, 3) their preferred learning style or 4) their confidence in taking responsibility for their own learning. In order to do this one needed something to measure against and so the first cohort of students was taught using a more conventional talk and chalk style of didactic lecturing and this was applied to undergraduate and postgraduate students in cohort 1 during the 2016-17 academic year. The second cohort were taught the same modules and materials as cohort 1 but using an active, flipped classroom approach during the 2017-18 academic year.

7.2.2 Hypotheses and outputs

The four research questions outlined in 7.2.1 above were refined into the 5 hypotheses set out below and results, discussed in findings and discussion chapters, are summarised here with reference to literature and engineering education practice as appropriate.

H1 – An active teaching approach impacts positively upon a learner's desire to learn when compared to a passive teaching approach. ***Outcome: partially rejected.***

When looking at the importance of knowledge for engineers, respondents agreed that whilst they had always felt knowledge to be important, the teaching in cohort 2 had reinforced that view. This could mean that active teaching does impact positively when it comes to stressing key facts but the same was not true of the importance of skills where there was no supportable evidence of any impact upon a learner's desire to learn new skills. Evidence of the existence of 'pull' factors (Fig 2.3, p.25) is seen to be supported for their willingness to learn new knowledge but much less so for their willingness to learn new skills. This was a surprise in that undergraduates seem to acknowledge that certain skills are key e.g. communication or team working skills but that the teaching had only moved their focus rather than improved their views. Postgraduates generally felt similar, one respondent did feel that the act of doing something was what was needed more than the knowledge of that act e.g. practicing presentation skills. This is also somewhat of a surprise as engineering students would be expected to desire practical experience (Everett et al, 2014) and some level of guidance e.g. micro-lectures as seen in Jackson and Ward's (2012) CBL research and other small cohort research (Kerr, 2015). When asked about the opportunity to improve, all students in all cohorts agreed this to be important. However, there was no clear indication of the teaching style having any direct impact on this aspect. Thus, there was an acknowledgement of impact through active teaching (supporting Locke and Latham, 2002; and Arshad et al., 2015) but that it reinforced rather than having a specifically positive impact upon the desire to learn or to boost academic achievement. This is an interesting finding in that it points to there being little if any negative impact of using a flipped classroom approach in larger class sizes. An even more interesting finding for this hypothesis, when looking at gender differences, shows that active teaching may be more effective in stimulating curiosity and a willingness to question in females. The latter finding is worthy of further investigative research into the wider engagement of females within engineering and thus within engineering education.

H2 – A learner's preferred learning style can be affected by being exposed to an active teaching approach. ***Outcome: partially supported.***

Undergraduate cohort 1 and both postgraduate cohorts showed a slight shift in learning style preference towards a more kinaesthetic style (practical hands on), and this was evident in responses about further practice needed. Interestingly this contradicts the outcome discussed above where little or no supportable evidence emerged for a rise in a student's willingness to learn new skills. This tends to indicate that both active and passive teaching styles can be seen to impact an engineering student's preferred learning style. Active teaching also appears to create a shift towards listening and analysis in students, good for budding engineers, but no firm conclusion can be drawn as cultural aspects may have been at work in this area. However, undergraduate cohort 2 showed no shift in preference but at interview felt that active teaching has to be carried out in the correct context. This may be a key finding for engineering educators since an active teaching style was thought by the researcher to generally have more impact and thus challenges earlier findings in support of links between teaching style and learning style preference (Felder and Silverman, 1988). However, it supports rather than challenges Clark, R's (2009) research which found these links to be more relevant for improving teaching practice rather than affecting learning style.

H3 – A learner's preferred thinking style can be affected by being exposed to an active teaching approach. ***Outcome: rejected.***

No findings from quantitative analysis or qualitative responses show a definite change in either undergraduate or postgraduate thinking style preferences but the small changes that are present indicate postgraduates differ from undergraduates by a small shift away from reflective thinking rather than towards reflection. The overall results may be slightly affected by one or two extreme changes in individuals (as shown in Figs 4.2, 4.3, 4.5 and 4.6, 4.12, to 4.14, 4.16 to 4.18) but taken as cohorts, no impact is evident of active teaching having an effect on preferred thinking style for engineering students.

H4 – A learner's belief in their current abilities (self-esteem) is affected by being exposed to an active teaching approach. ***Outcome: partially supported.***

There is an indication that active teaching enables better planning, organising, questioning and responsibility in engineering learners for both undergraduate and postgraduate respondents and is potentially a key finding given that it augments and improves their skill levels in these areas and should give more confidence in applying these skills. This supports the view from undergraduates of a shift in focus in the application or use of skills rather than a direct willingness to learn new skills. Students who were already used to active teaching were not affected as much in this category as those who were used to passive teaching, so the impact may seem less obvious than it is. However, there is also an indication that competing pressures on student time may have affected undergraduate cohort 2 more than cohort 1. This might be an unintended result of active teaching but is something to think about when designing programmes of study in engineering and has also been found in other large cohort studies too (Gullayanon, 2014; Lombardini et al, 2018).

Postgraduate responses may have been affected by different levels of confidence between cohorts when they started the course as postgraduate cohort 2 indicated only a small rise in self-esteem compared with a larger rise for postgraduate cohort 1. However, checks for differences through mean scores before the start of teaching showed no supporting evidence. Postgraduate responses across gender show that males grew less confident during the active teaching period where females remained at previous levels or actually improved their confidence levels thus contradicting Bleidorn et al. (2016) where they found males in early adulthood to have more self-esteem than females. One could argue that the effect on a learner depends on the ability of the teacher to deliver the learning in an effective way. One very interesting outcome shows that females are more affected by active teaching than males and this is an area worthy of further research given the context of females in engineering.

H5 – The learner experiences a rise in their level of self-efficacy and takes more responsibility for their learning when exposed to an active teaching approach. ***Outcome: supported.***

There is evidence of more self-reliance in both undergraduates and postgraduates when exposed to active teaching, supporting the findings of Bland (2006) and Ojunugwa et al. (2015). Interview responses from cohort 2 respondents clearly indicate that active questioning, discussion and pre-reading are now very important to them and has given them more confidence to discuss issues without fear of ridicule (Alexander, 2008 and 2013). This is interesting in that students from all backgrounds still fear the 'put down' response to a question when in a large class and that active teaching is a possible method to reduce or remove that fear. This is a vital issue for engineers in the workplace because they need to be curious and ask questions in order to solve problems and achieve their respective goals. One common factor for all cohorts is the need to take more responsibility for their own learning through improved planning. This brings all researched elements (knowledge, skills, improvement and confidence) nicely together with an interesting twist in that active teaching requires all of these factors to be present before a lesson but the act of preparation itself may also lead to a reluctance to take further notes or record key outputs from class discussions. This finding is potentially a counter-productive impact of active teaching, especially for engineering students who need to record facts and progress, that needs to be considered when planning the depth of immersive learning sessions. There is probably a need to introduce more reflective, formative elements in line with constructivist theory (Wood, Bruner and Ross, 1976; Vygotsky, 1978; Kolb, 1984; Bishop and Verleger, 2013).

Once again, we see a clear gender difference for self-efficacy where active teaching is used. Females in undergraduate cohort 2 show more realism in what they can expect to do and thus take on more responsibility for their own learning in contrast to the findings of Huang (2013) and shows evidence of differences for engineering students. The overall impression is that students from actively taught cohorts are more motivated and will ‘push’ themselves more to achieve better outcomes (see Concannon and Barrow, 2010; Schunk, 2012; Hsieh et al., 2012; Shkullaku, 2013).

7.3 Final conclusions

The previous narrative discussed some of the ways in which the research design may have been improved to enhance results. However, whilst the research did not provide as clear a set of results as would be preferred, it did identify some key aspects of large group, flipped classroom teaching in engineering education that were not readily evident at the time of starting. Set out below are the aspects that have been shown to support or contradict existing research (those with references) and some that have emerged from this research that may need further exploration through other studies.

- ✓ There was some support for the flipped classroom approach reinforcing rather than having a specific positive or negative impact upon the desire to learn when used in larger class sizes (Tucker, 2012; Jackson and Ward, 2012; Horn, 2013, Gullayanon, 2014; Reidsema et al, 2017; Lombardini et al, 2018);
- ✓ Active teaching has to be carried out in the correct engineering context and needs to be managed carefully to ensure the appropriate exposure to and use of discursive techniques (Alexander 2008 and 2013; Clark and Andrews, 2014);
- ✓ There is an indication that active teaching enables better planning, organising, questioning and responsibility in engineering learners (Binson, 2009; Everett et al, 2014);
- ✓ Contrary to findings from Huang (2013) females appear to be more affected by active teaching than males, in particular, active teaching may be more effective in stimulating curiosity in budding female engineers;

- ✓ There is evidence of more self-reliance in students exposed to active teaching with the motivation for this being result driven (Ojunugwa et al., 2015: Abeysekera and Dawson, 2015);
- ✓ Contradictory evidence on the importance of skills development for engineering students needs clarification (SALEIE, 2015; IET, 2016);
- ✓ Females show more realism in their expectations and willingness to take on more responsibility for their own learning when exposed to active teaching, supporting a key objective of this research from Sections 1.2.3 and 1.3, where results (achievement) motivate the desire to take on responsibility through improved self-belief and self-motivation (Abeysekera and Dawson, 2015);
- ✓ There is no support for active teaching having an effect on preferred thinking style, despite Benziger and Sohn's (2013) views on thinking style. However, many agree that critical thinking skills are required for engineering learners (Paul, 1984; Kadir, 2007; Benziger, 2013). A specific research looking into the development of critical thinking through active teaching may identify an actual effect; and
- ✓ Active teaching is a possible approach to engineering education that may reduce or remove the fear of contributing in a large class scenario.

7.4 Research review

The research as carried out has led to some interesting outcomes and indicates overall support for the use of flipped classroom techniques. It has not been successful in proving the use of such techniques to be suitable for all situations in engineering education although it has given weight to the assertion that active teaching can be useful for certain types of knowledge transfer activities, even in large class scenarios supporting the findings of Reidsema et al (2015). The identification of a likely measure of effectiveness in terms of class population would be an interesting piece of research and potentially useful for curricular planning i.e. a sliding scale of class size against pedagogical approach. This might also need to be set out by topic i.e. the most likely topics for use of a flipped or curiosity-based learning approach in engineering education.

The research in its current form took too long and might have been better focussed through qualitative measures that used the teaching, student reactions and interviews to ascertain effectiveness. The issue with such an approach would be the lack of a control group, nothing to compare against and was one reason why a quantitative (longer term) method was adopted and a questionnaire was the main survey instrument. Mason et al. (2013), Ossman and Bucks (2014) and Jungic et al. (2015) indicated that instructors should develop pre-test activities to use before classes start to assess the preparation level of those attending – the research reported here did not do this and so pre-class tests should be something to consider in future research of a similar nature. The fact that there were no major differences in the make-up of participants between cohort 1 and cohort 2 (either undergraduate or postgraduate) was probably more down to luck than robust design although using different respondent cohorts is a valid methodology. As a method to shorten research timescales, teaching could have been modified during the timespan of a single module to try and detect any impact as the teaching style was modified. This would be an interesting way to try a similar cohort-based study in future, would avoid changed target research populations and would potentially produce more robust and comparable outputs. However, it would also depend on all students turning up for all of the lectures to provide a true comparison and this too could not be guaranteed.

Analysing the data collected was a long and sometimes tedious job, especially when statistic after statistic showed no changes or no statistically significant outputs. It was a little surprising that the majority of normality tests showed the data to be non-normally distributed which limited the overall tests that were available to non-parametric tests (using median scores rather than means). With more responses from the target population this may have been avoided and was one aspect that was changed after the first data collection from undergraduate respondents. This is a key learning point for future research to ensure the data collection method is as effective as possible from the start and that any pilot study is as representative of the actual research as possible.

Gender differences are seen here in many responses although not all of them were statistically significant so merely suggest a trend or tendency. There is a lack of female respondents in most engineering research, especially engineering education and so a more targeted study using a qualitative approach could be a better method of researching gender differences in engineering education. However, those that were statistically significant or of further interest are identified in the next section as areas for further research.

The research concentrated on assessing competences and did not attempt to measure summative outcomes for students exposed to the flipped classroom versus didactic approaches. A final outcomes analysis may have uncovered further indications of the effectiveness of flipping the classroom but was not part of this research design, would have added yet further time to the data collection and required further permissions from participants to use their anonymised summative results.

7.5 Further research aspects

The need for more research in some areas is identified through lack of categorical outputs from the research reported here. It is intended to work on areas noted below and design further studies to better clarify the issues and improve the researcher's teaching practice.

- ✓ Male respondents did not change their responses in any category yet female respondents did in all undergraduate and postgraduate cohorts. This is quite an odd result, one would have expected at least some changes for male respondents to be evident. This warrants a new study focussed specifically on this issue;

- ✓ Females may be affected more by active teaching than males. This deserves further research, especially in the area of raised curiosity when we find ourselves at a time of seriously low engineering manpower resource generally, with the identified need for a greater proportion of female engineers;

- ✓ There could be a gender preference for type of assessment because male respondents indicated a tendency to prefer written exams (easier to assess knowledge) whilst female respondents were more in favour of coursework or other assessment types (easier to assess skills). Research could look into existing cohorts, respective results for males versus females on different assessment types and new cohorts in these topic areas;

- ✓ Active teaching may increase the workload for students and thus become counter-productive from a stress level perspective. This would need a much deeper investigation of environmental factors and would be better accomplished as a series of related research studies across a number of university settings;

- ✓ There is an indication that active teaching imparts a more assertive attitude and confidence in answering directly when giving an opinion. The key factors for this to occur would need to be identified through any research study should such an effect prove to be true;

- ✓ Research into class sizes and effective use of flipped/CBL style approaches with an indication of suitable topics may be needed for better pedagogical design; and

- ✓ The existence of learner preferred thinking styles is brought into question through this study. Is there a more suitable instrument to collect data on HE student thinking styles? The fact that the instrument used in this research found very few overall differences does not mean there were none. A more complete review of research in this area would be useful in determining a) the validity of this concept in engineering education research, b) whether there is a need to identify changed critical thinking skills rather than generic thinking style and c) if appropriate, a suitable instrument to use in future engineering education research.

7.6 Overall conclusions

The research set out to determine whether there might be a new theory or pedagogical model to be developed from which engineering students and teachers could benefit. This model has not emerged yet but it is interesting to note that elements of learner ‘pull’ and also teacher ‘push’ are evident (see Figure 2.3, p.25). The key additional elements identified for incorporation into any new model are gender-based differences. The areas for elimination from future models (pending further research) include ethnicity, age-related differences where the respondent rate is small, learning style preference and, thinking style preference. The last two items in particular need further literature and desk-based review before further field research that includes them is carried out. Specifically, learning style differences are surprisingly minimal, especially in undergraduate cohorts, as learning style was thought to be a prime contender for change due to an active teaching approach. On the positive side there are clear indications of greater self-belief in what might be possible, albeit tinged with more realistic expectations, and greater motivation to take responsibility for one’s own learning. These aspects were expected but given the lack of clear evidence for other changes, require further underpinning to be sure the results are accurate and able to be reproduced in future research.

The negative effects of using an active teaching approach in HE would also benefit from a deeper study. Especially the unintended outputs discussed in the findings such as stress and lack of teamwork through additional workload, lack of evidence regarding learning style changes, a lesser effect on self-esteem during active teaching than passive and a reduction in willingness to take class notes during the actively taught cohort.

This research has uncovered support for the use of flipped classroom style active teaching in engineering education, even in larger cohorts, and has therefore achieved a measure of new knowledge. In particular there is good support for active teaching being more effective in increasing self-efficacy, especially in females, reasonable support for it effecting a rise in self-esteem and some support for it having an effect on learning style. There is less support for there being an impact on a learner's desire to learn and no support for it making any difference to the way a learner thinks about their learning. A mixed set of results with some unexpected outcomes. However, as with many research projects, the analysis has uncovered further aspects that are still unclear and that would benefit from future studies. The researcher is looking forward to further work in these areas and to publishing subsets of this research for wider debate in academic circles.

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10. Appendices

The following Appendices are those referred to in the thesis, they are presented in order of appearance.

Appendix 1 – Research Onion Model

Appendix 2 – Example participant interviews research study information sheet.

Appendix 3 – Example consent form

Appendix 4 – Quantitative data collection instrument Undergraduate cohorts at Cohort 1

Appendix 5 – Quantitative data collection instrument Undergraduate cohorts at Cohort 2 and all Postgraduate cohorts

Appendix 6 – Semi-structured interview guide

Appendix 7 – Ethical Approval

Appendix 8 – Research project plan

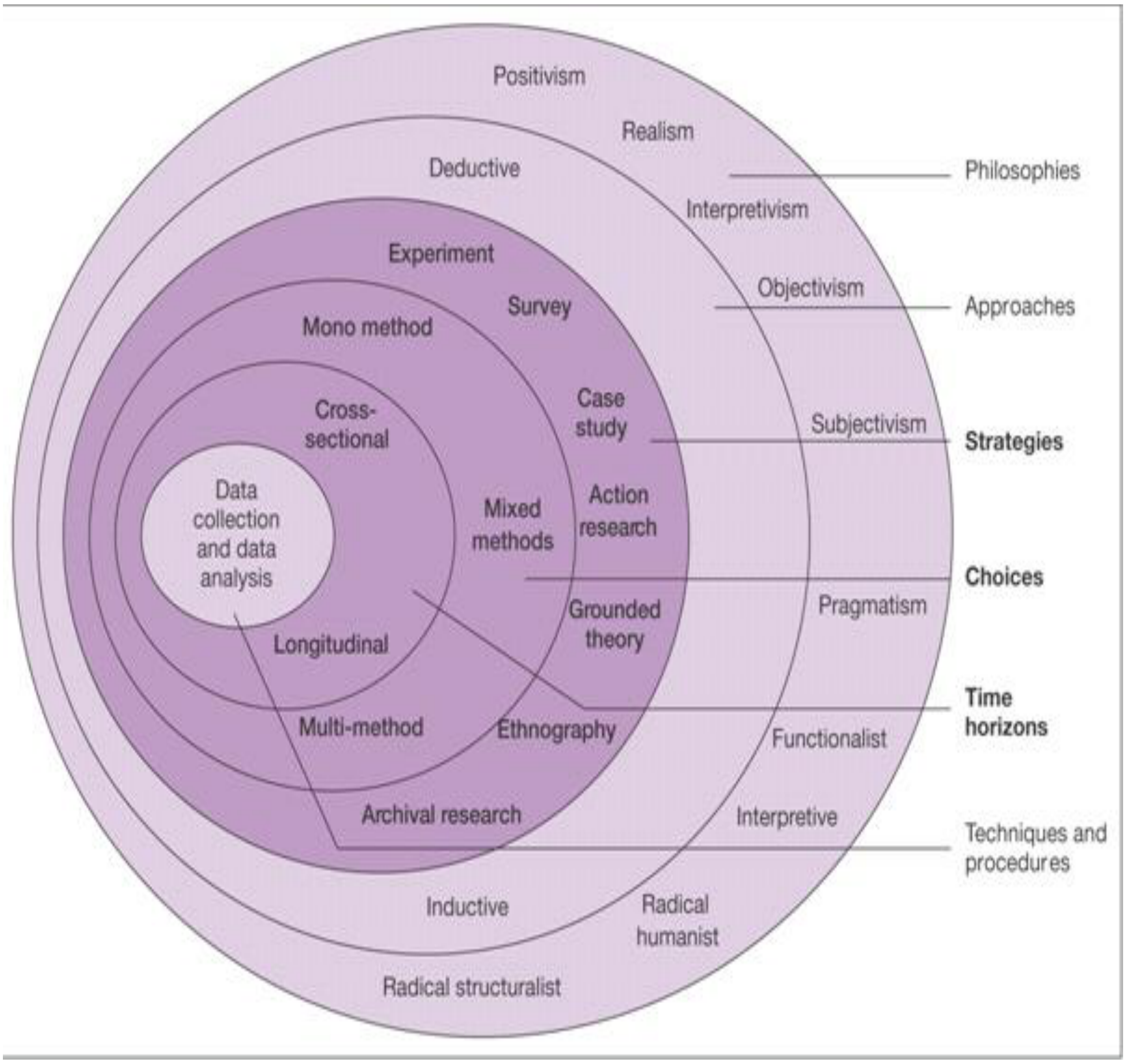
Appendix 9 – Experiential Learning Cycle (Kolb, 1984)

Appendix 10 – Supporting SPSS Analysis Tables

Appendix 11 – Precis of all post teaching interviews

Appendix 12 – Teaching approaches adopted during this research

Appendix 1 – Saunders' et al. (2009) research onion model.



Appendix 2 – Example participant interviews research study information sheet.

Title of the research study:

Measuring the effectiveness of a lecture-based teaching approach and comparing it with an active teaching approach in electronic engineering students

Dear student, I am inviting you to take part in a research study I am undertaking and the information below gives details of the research allowing you to decide whether you wish to participate in the study.

What is the research about?

Assessing whether an active teaching approach, where discussion is encouraged and the order of teaching may be altered, compared to a more normal passive approach, such as lectures using slides or blackboards, can improve the effectiveness of teaching for electronic engineering students.

Why am I being asked to take part?

You have been selected because you are in the first group of students to start our revised curriculum for engineering degree courses in electronics and I feel you are in an ideal position to inform teaching practices in the department as the curriculum develops.

What does it mean for me?

Taking part would mean you completing a written questionnaire before we start teaching on this module and the same written questionnaire at the end of this term when the formal teaching ends and labs/practical sessions start. You may also be one of 10% of participants who will be selected at random to participate in a short face-to-face interview with the researcher. The questionnaire will take approximately 15 minutes to complete each time and the interview, to be held in the spring term, would last for approximately 30 minutes.

Are there any risks or benefits?

There are no personal risks or disadvantages to taking part in the research study as the study has nothing to do with your progress on the course. If you decide to go ahead you will be asked to sign a consent form to make sure that you fully understand what you are agreeing to. A further consent form will be made available at interview. The research has been approved by the faculty and ethics committee at this university and at Staffordshire University where the researcher is studying.

There are no personal benefits for the participants but any knowledge gained through the research will be made available to the department to consider how teaching approaches might be put in place to improve the student experience in future.

Your participation is completely voluntary. You can change your mind at any point without giving a reason for doing so and withdraw at any time up to the point at which the data becomes aggregated for analysis purposes. You are not obliged to answer questions in the written questionnaire or during the interview if you would prefer not to answer them.

Will I be identified in the report?

No. None of the information you provide in questionnaires or at interview will identify you or be attributed to you and your identity will remain anonymous thus you will be protected in the final report. In addition, all information provided by you will be confidential and accessed only by the researcher. Transcripts of interviews will be stored securely during the research and will be destroyed in accordance with university procedures that are in force when the project is completed.

Further information.

This research is being undertaken for the purpose of completing a dissertation for a professional Doctorate in Education through Staffordshire University. If you have any queries or questions related to this research, please contact me on 01904 324728, or by email at noel.jackson@york.ac.uk . If you have any concerns about this research, please feel free to contact my supervisor, Dr. Amanda Hughes. Her email address is A.C.Hughes@staffs.ac.uk

If you would like to receive a copy of the research output please leave an email address on the space provided on the Consent Form.

Thank you for taking the time to read this information sheet.

Noel R Jackson (Lecturer, Teaching and Scholarship)

Deputy Chair Board of Examiners

Department of Electronics

University of York

01904 324728

noel.jackson@york.ac.uk

Appendix 3 – Example consent form.

Research Project Area: Measuring the effectiveness of a lecture-based teaching approach and comparing it with an active teaching approach in electronic engineering students. *Please tick the appropriate box for each question:*

1. Has the purpose of the research been explained to you?

   Yes □ No □

2. Have you seen/been given an information sheet about the project

   Yes □ No □

3. Has there been an opportunity to ask the researcher questions about the project?

   Yes □ No □

4. Do you understand that if you do not wish to answer a question you may say so or move on without making an answer?

   Yes □ No □

5. Do you understand that you may stop answering questions or leave the interview at any time without giving a reason?

   Yes □ No □

6. Do you understand that an audio recording will be taken at interview as well as written notes to aid accuracy of data responses?

   Yes □ No □

7. Would you like to see the output of the research once completed?

   Yes □ No □

I understand that all data presented in whatever format will be anonymous. I confirm that I have seen this information prior to taking part in the research and I agree to take part in this research.

Signature:______________________________ Date:__________________

Name (*Block Capitals please*): _____________________________________

Appendix 4 – Quantitative data collection instrument Undergraduate cohorts at Pre and Post

Q1 Please write your University of York Student Name (e.g. nj123)

- ❍ Student Name ____________________

Q2 Please insert today's date.

- ❍ ____________________

Q3 Please indicate your age group as at your last birthday

- ❍ Under 18 (1)
- ❍ 18 - 24 (2)
- ❍ 25 - 34 (3)
- ❍ 35 - 44 (4)
- ❍ 45 - 54 (5)
- ❍ 55 - 64 (6)
- ❍ 65 or older (7)

Q4 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q5 In what country did you attend secondary/high school?

- ❍ England (1)
- ❍ Scotland (2)
- ❍ Wales (3)
- ❍ China (4)
- ❍ India (5)
- ❍ Malaysia (6)
- ❍ Other (7)

Q6 Please indicate how well you agree with the following statements in relation to electronic engineering students.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. Knowledge of accounting and finance is important	❍	❍	❍	❍	❍
b. Knowledge of sales and marketing is important	❍	❍	❍	❍	❍
c. Knowledge of human resource management is important	❍	❍	❍	❍	❍
d. Knowledge of project planning is important	❍	❍	❍	❍	❍
e. Knowledge of design and production is important	❍	❍	❍	❍	❍
f. Knowledge of quality management is important	❍	❍	❍	❍	❍
g. Knowledge of legal aspects of business is important	❍	❍	❍	❍	❍

Q7 Please indicate how well you agree with the following statements in relation to electronic engineering students.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. The ability to give effective presentations is important	❍	❍	❍	❍	❍
b. The ability to produce quality reports is important	❍	❍	❍	❍	❍
c. The ability to be creative is important	❍	❍	❍	❍	❍
d. The ability to be able to solve problems is important	❍	❍	❍	❍	❍
e. The ability to formulate good questions is important	❍	❍	❍	❍	❍
f. The ability to work effectively in a team is important	❍	❍	❍	❍	❍
g. The ability to design and produce products/services is important	❍	❍	❍	❍	❍
h. The ability to communicate effectively is important	❍	❍	❍	❍	❍
i. The ability to use discussion to investigate an issue is important	❍	❍	❍	❍	❍

Q8 Do you think the opportunity to improve some or all of the skills in question 7 during your university course is important?

- ❍ Definitely not (1)
- ❍ Probably not (2)
- ❍ Not sure (3)
- ❍ Probably yes (4)
- ❍ Definitely yes (5)

Q9 This question asks you to indicate your current capabilities in general situations.

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
a. I can always manage to solve difficult problems if I try hard enough	❍	❍	❍	❍	❍
b. If someone opposes me I can find means and ways to get what I want	❍	❍	❍	❍	❍
c. It is easy for me to stick to my aims and accomplish my goals	❍	❍	❍	❍	❍
d. I am confident that I could deal efficiently with unexpected events	❍	❍	❍	❍	❍
e. Thanks to my resourcefulness, I know how to handle unforeseen situations	❍	❍	❍	❍	❍
f. If the unexpected happens I rarely need to seek advice on how to proceed	❍	❍	❍	❍	❍
g. I can solve most problems if I invest the necessary effort	❍	❍	❍	❍	❍
h. Colleagues find it difficult to persuade me to proceed differently	❍	❍	❍	❍	❍
i. I can remain calm when facing difficulties	❍	❍	❍	❍	❍
j. When I am confronted with a problem I can usually find several solutions	❍	❍	❍	❍	❍
k. No matter what comes my way, I am usually able to handle it	❍	❍	❍	❍	❍
l. I am rarely uncomfortable when faced with challenging situations	❍	❍	❍	❍	❍
m. If I am stuck on a problem, I can usually think of something to do	❍	❍	❍	❍	❍
n. I can be relied upon to make sensible judgments	❍	❍	❍	❍	❍
o. I am rarely persuaded to change direction once I have set my mind on an objective	❍	❍	❍	❍	❍

Q10 Thinking about the specific skills below, for each statement, indicate how confident you are that you could perform that skill.

	Not at all confident				Completely Confident
a. Finish technical reports or assignments on time	❍	❍	❍	❍	❍
b. Concentrate on technical engineering subjects	❍	❍	❍	❍	❍
c. Take class notes that will be useful in technical or engineering projects	❍	❍	❍	❍	❍
d. Use the library and search engines for engineering research	❍	❍	❍	❍	❍
e. Plan and organise your workload and technical study space	❍	❍	❍	❍	❍
f. Remember 'Engineering' lecture content	❍	❍	❍	❍	❍
g. Remember 'Engineering Lab' practical session outputs	❍	❍	❍	❍	❍
h. Motivate yourself to study engineering	❍	❍	❍	❍	❍
i. Take part in class based engineering or technical discussions	❍	❍	❍	❍	❍
j. Review instructions and estimate how long it will take to complete an engineering task	❍	❍	❍	❍	❍
k. Design and construct an experiment that maintains precisely specified conditions	❍	❍	❍	❍	❍
l. Lead a technical team to develop a new product to a successful result	❍	❍	❍	❍	❍
m. Document technical procedures so that someone else could use them to produce the same result	❍	❍	❍	❍	❍
n. Write a clear and concise engineering project plan	❍	❍	❍	❍	❍

Q11 When I operate new equipment I generally (please select **one** answer)

❍ Read the instructions
❍ Listen to someone explaining it
❍ Jump in and have a go, work it out as I use it

Q12 If I am going somewhere new and need directions I usually (please select **one** answer)

- ❍ Look at a map
- ❍ Ask someone for spoken directions
- ❍ Go in the general direction and use my instincts

Q13 If I am cooking a new dish I generally (please select **one** answer)

- ❍ Follow a recipe
- ❍ Ask a friend to explain how they do it
- ❍ Get what seem to be the right ingredients and taste as I go

Q14 If I am teaching someone something new I tend to (please select **one** answer)

- ❍ Write instructions
- ❍ Explain verbally
- ❍ Demonstrate and then watch them have a go

Q15 In general conversation I would tend to say (please select **one** answer)

- ❍ Watch how I do it
- ❍ Listen to me explain
- ❍ You have a go

Q16 During my free time I would rather (please select **one** answer)

- ❍ Visit a museum or gallery
- ❍ Listen to music or radio and generally relax
- ❍ Play sport or do something like gardening

Q17 If I were choosing a holiday I would prefer to (please select **one** answer)

- ❍ Read the brochures
- ❍ Listen to recommendations
- ❍ Imagine myself actually at the destination

Q18 If I were out shopping for clothes I would tend to (please select **one** answer)

- ❍ Imagine what they would look like on me
- ❍ Discuss them with shop staff or friends
- ❍ Try them on

Q19 When I concentrate, I most often (please select **one** answer)

- ❍ Focus on the words or pictures in front of me
- ❍ Discuss the problem and possible solutions in my head
- ❍ Move around a lot, fiddle with pencils/pens and touch things

Q20 When I am learning a new skill, I feel most comfortable when (please select **one** answer)

- ❍ Watching what the teacher is doing
- ❍ Talking through with the teacher what it is I am expected to do
- ❍ Giving it a try and working it out as I go

Q21 There are 15 sets of words shown below, for each set of 4 words, choose the TWO that best describe you e.g. if they were Sensitive, Cautious, Orderly and Precise - you might choose Cautious and Precise and please check **TWO** boxes on each row.

Question 1	❑ Imaginative	❑ Investigative	❑ Realistic	❑ Analytical
Question 2	❑ Organised	❑ Adaptable	❑ Critical	❑ Inquisitive
Question 3	❑ Debating	❑ Getting to the point	❑ Creating	❑ Relating
Question 4	❑ Personal	❑ Practical	❑ Academic	❑ Adventurous
Question 5	❑ Precise	❑ Flexible	❑ Systematic	❑ Inventive
Question 6	❑ Sharing	❑ Orderly	❑ Sensible	❑ Independent
Question 7	❑ Competitive	❑ Perfectionist	❑ Cooperative	❑ Logical
Question 8	❑ Intellectual	❑ Sensitive	❑ Hardworking	❑ Risk-Taking
Question 9	❑ Reader	❑ People Person	❑ Problem Solver	❑ Planner
Question 10	❑ Memorize	❑ Associate	❑ Think-Through	❑ Originate
Question 11	❑ Changer	❑ Judger	❑ Spontaneous	❑ Wants Direction
Question 12	❑ Communicating	❑ Discovering	❑ Cautious	❑ Reasoning
Question 13	❑ Challenging	❑ Practicing	❑ Caring	❑ Examining
Question 14	❑ Completing Work	❑ Seeing Possibilities	❑ Gaining Ideas	❑ Interpreting
Question 15	❑ Doing	❑ Feeling	❑ Thinking	❑ Experimenting

Thanks for your time in completing this survey.

Appendix 5 – Quantitative data collection instrument Undergraduate cohorts t3/t4 and all Postgraduate cohorts

Q1 Please write your student username (e.g. nj123)

- ❍ ____________________

Q2 Please write today's date.

- ❍ ____________________

Q3 Please indicate your age group as at your last birthday

- ❍ Under 18 (1)
- ❍ 18 - 24 (2)
- ❍ 25 - 34 (3)
- ❍ 35 - 44 (4)
- ❍ 45 - 54 (5)
- ❍ 55 - 64 (6)
- ❍ 65 or older (7)

Q4 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q5 In what country did you attend secondary/high school?

- ❍ England (1)
- ❍ Scotland (2)
- ❍ Wales (3)
- ❍ China (4)
- ❍ India (5)
- ❍ Malaysia (6)
- ❍ Other (7)

Q6 About your undergraduate or previous education

Please select the option that most closely matches your previous study given that the terms 'passive' and 'active' in this context are simplified to indicate the following:

Passive study = Lecturer discourages discussion or debate within lessons

Active study = Lecturer encourages discussion and debate within lessons

- ❍ Passive study using formal lectures, workshops or guided investigation (1)
- ❍ Active study using informal lectures, workshops or guided investigation (2)

Q7 Please select your highest level of qualification before attending the MSc at York.

- Bachelors (BSc, BA, BEng etc.) (1)
- Masters (MSc, MA, MEng etc.) (2)
- Not Applicable (3)

Q8 What is your ethnic group?

Please choose one option that best describes your ethnic group or background

White

- English/Welsh/Scottish/Northern Irish/British (1)
- Irish (2)
- Any other White background (3)

Mixed/Multiple ethnic groups

- White and Black Caribbean (4)
- White and Black African (5)
- White and Asian (6)
- Any other Mixed/Multiple ethnic background (7)

Asian/Asian British

- Indian (8)
- Pakistani (9)
- Bangladeshi (10)
- Chinese (11)
- Any other Asian background (12)

Black/ African/Caribbean/Black British

- African (13)
- Caribbean (14)
- Any other Black/African/Caribbean background

Other ethnic group

- Arab (15)
- Any other ethnic group (16)

Q9 Please indicate how well you agree with the following statements in relation to electronic engineering students.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. Knowledge of accounting and finance is important	❍	❍	❍	❍	❍
b. Knowledge of sales and marketing is important	❍	❍	❍	❍	❍
c. Knowledge of human resource management is important	❍	❍	❍	❍	❍
d. Knowledge of project planning is important	❍	❍	❍	❍	❍
e. Knowledge of design and production is important	❍	❍	❍	❍	❍
f. Knowledge of quality management is important	❍	❍	❍	❍	❍
g. Knowledge of legal aspects of business is important	❍	❍	❍	❍	❍

Q10 Please indicate how well you agree with the following statements in relation to electronic engineering students.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. The ability to give effective presentations is important	❍	❍	❍	❍	❍
b. The ability to produce quality reports is important	❍	❍	❍	❍	❍
c. The ability to be creative is important	❍	❍	❍	❍	❍
d. The ability to be able to solve problems is important	❍	❍	❍	❍	❍
e. The ability to formulate good questions is important	❍	❍	❍	❍	❍
f. The ability to work effectively in a team is important	❍	❍	❍	❍	❍
g. The ability to design and produce products/services is important	❍	❍	❍	❍	❍
h. The ability to communicate effectively is important	❍	❍	❍	❍	❍
i. The ability to use discussion to investigate an issue is important	❍	❍	❍	❍	❍

Q11 Do you think the opportunity to improve some or all of the skills in question 10 during your university course is important?

- ❍ Definitely not (1)
- ❍ Probably not (2)
- ❍ Not sure (3)
- ❍ Probably yes (4)
- ❍ Definitely yes (5)

Q12 This question asks you to indicate your current capabilities in general situations.

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
a. I can always manage to solve difficult problems if I try hard enough	❍	❍	❍	❍	❍
b. If someone opposes me I can find means and ways to get what I want	❍	❍	❍	❍	❍
c. It is easy for me to stick to my aims and accomplish my goals	❍	❍	❍	❍	❍
d. I am confident that I could deal efficiently with unexpected events	❍	❍	❍	❍	❍
e. Thanks to my resourcefulness, I know how to handle unforeseen situations	❍	❍	❍	❍	❍
f. If the unexpected happens I rarely need to seek advice on how to proceed	❍	❍	❍	❍	❍
g. I can solve most problems if I invest the necessary effort	❍	❍	❍	❍	❍
h. Colleagues find it difficult to persuade me to proceed differently	❍	❍	❍	❍	❍
i. I can remain calm when facing difficulties	❍	❍	❍	❍	❍
j. When I am confronted with a problem I can usually find several solutions	❍	❍	❍	❍	❍
k. No matter what comes my way, I am usually able to handle it	❍	❍	❍	❍	❍
l. I am rarely uncomfortable when faced with challenging situations	❍	❍	❍	❍	❍
m. If I am stuck on a problem, I can usually think of something to do	❍	❍	❍	❍	❍
n. I can be relied upon to make sensible judgments	❍	❍	❍	❍	❍
o. I am rarely persuaded to change direction once I have set my mind on an objective	❍	❍	❍	❍	❍

Q13 Thinking about the specific skills below, for each statement, indicate how confident you are that you could perform that skill.

	Not at all confident				Completely Confident
a. Finish technical reports or assignments on time	❍	❍	❍	❍	❍
b. Concentrate on technical engineering subjects	❍	❍	❍	❍	❍
c. Take class notes that will be useful in technical or engineering projects	❍	❍	❍	❍	❍
d. Use the library and search engines for engineering research	❍	❍	❍	❍	❍
e. Plan and organise your workload and technical study space	❍	❍	❍	❍	❍
f. Remember 'Engineering Design' lecture content	❍	❍	❍	❍	❍
g. Remember 'Engineering Design' practical session outputs	❍	❍	❍	❍	❍
h. Motivate yourself to study engineering	❍	❍	❍	❍	❍
i. Take part in class based engineering or technical discussions	❍	❍	❍	❍	❍
j. Review instructions and estimate how long it will take to complete an engineering task	❍	❍	❍	❍	❍
k. Design and construct an experiment that maintains precisely specified conditions	❍	❍	❍	❍	❍
l. Lead a technical team to develop; a new product to a successful result	❍	❍	❍	❍	❍
m. Document technical procedures so that someone else could use them to produce the same result	❍	❍	❍	❍	❍
n. Write a clear and concise engineering project plan	❍	❍	❍	❍	❍

Q14 When I operate new equipment I generally (please select **one** answer)

❍ Read the instructions
❍ Listen to someone explaining it
❍ Jump in and have a go, work it out as I use it

Q15 If I am going somewhere new and need directions I usually (please select **one** answer)

❍ Look at a map
❍ Ask someone for spoken directions
❍ Go in the general direction and use my instincts

Q16 If I am cooking a new dish I generally (please select **one** answer)

- ❍ Follow a recipe
- ❍ Ask a friend to explain how they do it
- ❍ Get what seem to be the right ingredients and taste as I go

Q17 If I am teaching someone something new I tend to (please select **one** answer)

- ❍ Write instructions
- ❍ Explain verbally
- ❍ Demonstrate and then watch them have a go

Q18 In general conversation I would tend to say (please select **one** answer)

- ❍ Watch how I do it
- ❍ Listen to me explain
- ❍ You have a go

Q19 During my free time I would rather (please select **one** answer)

- ❍ Visit a museum or gallery
- ❍ Listen to music and generally relax
- ❍ Play sport or do something like gardening

Q20 If I were choosing a holiday I would prefer to (please select **one** answer)

- ❍ Read the brochures
- ❍ Listen to recommendations
- ❍ Imagine myself actually at the destination

Q21 If I were out shopping for clothes I would tend to (please select **one** answer)

- ❍ Imagine what they would look like on me
- ❍ Discuss them with shop staff
- ❍ Try them on

Q22 When I concentrate, I most often (please select **one** answer)

- ❍ Focus on the words or pictures in front of me
- ❍ Discuss the problem and possible solutions in my head
- ❍ Move around a lot, fiddle with pencils/pens and touch things

Q23 When I am learning a new skill, I feel most comfortable when (please select **one** answer)

- ❍ Watching what the teacher is doing
- ❍ Talking through with the teacher what it is I am expected to do
- ❍ Giving it a try and working it out as I go

Q24 There are 15 sets of words shown below, for each set of 4 words, choose **the TWO** that best describe you e.g. if they were Sensitive, Cautious, Orderly and Precise - you might choose Cautious and Precise. ***Please check TWO boxes on each row***.

Set 1	❑ Imaginative	❑ Investigative	❑ Realistic	❑ Analytical
Set 2	❑ Organised	❑ Adaptable	❑ Critical	❑ Inquisitive
Set 3	❑ Debating	❑ Getting to the point	❑ Creating	❑ Relating
Set 4	❑ Personal	❑ Practical	❑ Academic	❑ Adventurous
Set 5	❑ Precise	❑ Flexible	❑ Systematic	❑ Inventive
Set 6	❑ Sharing	❑ Orderly	❑ Sensible	❑ Independent
Set 7	❑ Competitive	❑ Perfectionist	❑ Cooperative	❑ Logical
Set 8	❑ Intellectual	❑ Sensitive	❑ Hardworking	❑ Risk-Taking
Set 9	❑ Reader	❑ People Person	❑ Problem Solver	❑ Planner
Set 10	❑ Memorize	❑ Associate	❑ Think-Through	❑ Originate
Set 11	❑ Changer	❑ Judger	❑ Spontaneous	❑ Wants Direction
Set 12	❑ Communicating	❑ Discovering	❑ Cautious	❑ Reasoning
Set 13	❑ Challenging	❑ Practicing	❑ Caring	❑ Examining
Set 14	❑ Completing Work	❑ Seeing Possibilities	❑ Gaining Ideas	❑ Interpreting
Set 15	❑ Doing	❑ Feeling	❑ Thinking	❑ Experimenting

Thanks for your time in completing this survey.

Appendix 6 – Semi-structured interview guide

Theme	Question	Prompts
Knowledge requirements	Have you changed your mind on what you felt was important for electronics engineers to know?	• What has caused this? • Why did it change your view? • Have you looked into it at all?
Importance of key skills	Have you changed your mind on what you felt was important for electronics engineers to be skilled at?	• What has caused this? • Why did it change your view? • Have you looked into it at all?
Self concept	Do you consider your ability to do things has changed?	• In what ways? • For the better or worse? • What specifically do you think has caused this? • Anything that might help?
Self confidence	Do you think you have become more decisive or independent in your ability to study through the learning gained during this module?	• What makes you think this? • Key moments that have helped? • Key people that have helped?
Learning style	Has your learning approach altered in other modules since you started this one?	• Why? Or Why not? • What has changed? • Any other influencers that you can think of?
Thinking style	Do you consider the way you think about your education has been influenced during this module?	• Outside or due to this module? • In which ways? • Other key aspects?
Teaching style	Would you like to see more teaching delivered in this way?	• Do you like lectures? • Prefer discussion in class? • Team based tasks?

Appendix 7 – Ethical Approval

STAFFORDSHIRE UNIVERSITY

Dr Noel Morrison
Director of Student & Academic Services

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Mr Noel Jackson
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York YO41 1JW

18th July 2016

ETHICAL APPROVAL FEEDBACK (Proportionate)

Title of Study: **Professional Doctorate in Education – Thesis Research**

Student Name: **Noel Jackson**

Title of Project: **Measuring the effectiveness/impact of an active teaching approach compared to a didactic teaching approach in electronic engineering students**

Status of Approval: **Approved – Action Now Required**

Your project proposal has now been approved by the Faculty's Ethics Committee. You can now begin to work on your proposed study.

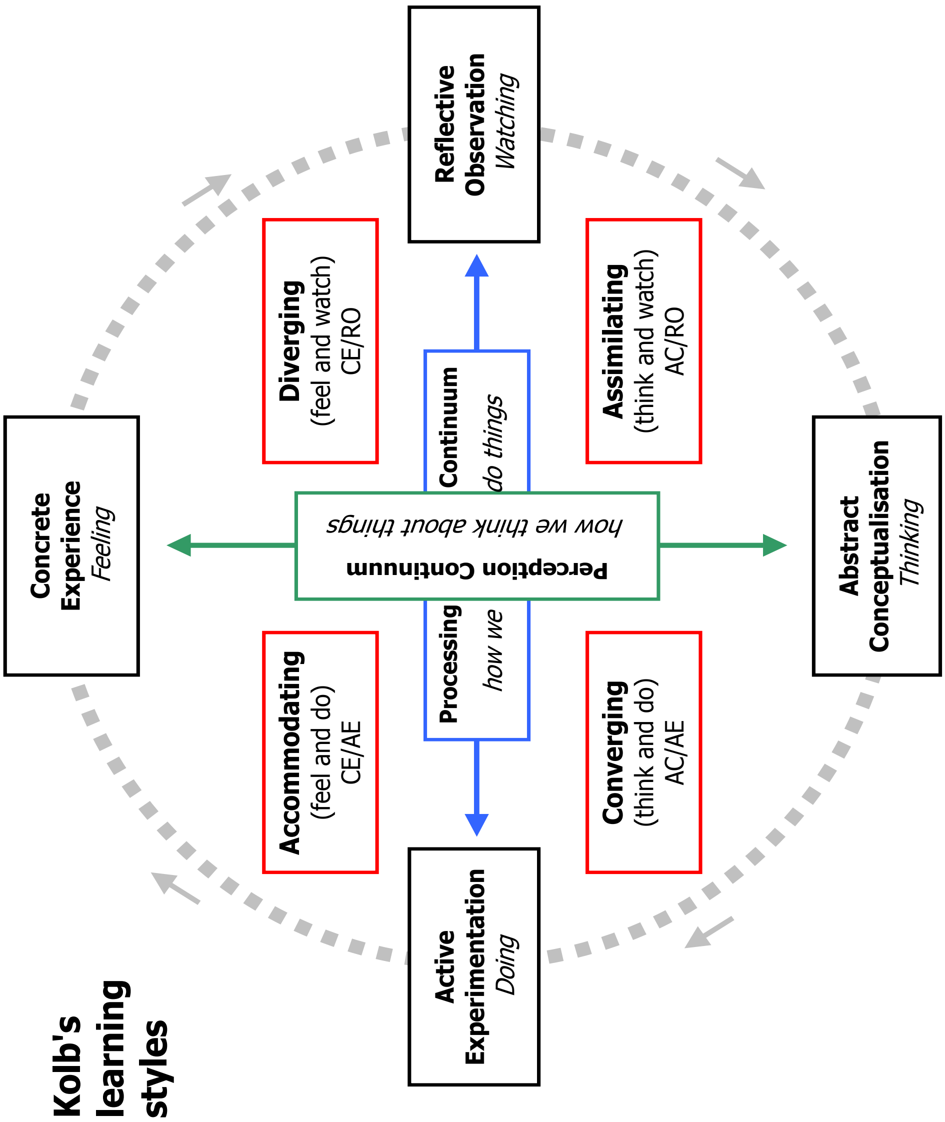
Your project must commence within 12 months for this approval to remain valid. If your project does not begin within this timescale a further application for ethical approval must be made.

Sharon Inglis .... Date: 18th July 2016
Chair of the Faculty of Business Ethics Panel

Appendix 8 – Research project plan

Dates	Activity
06/06/16	Research proposal ready for agreement to continue submitted.
20/06/16	Complete and signed off ethical approval form submitted.
28/06/16	Feedback received at the latest by this date ready for viva.
29/06/16	Research proposal viva.
11/07/16	Reflective report on viva (300 words).
31/07/16	Review research instrument for format, consistency and usage. Ensure SPSS statistical analysis elements are set up to compare the appropriate parameters
30/09/16	Final adjustments and tests done with the data collection process ready for introduction to incoming year 1 students
26/10/16 to 30/10/16	Incoming year 1 students will be approached and invited to complete the pre-questionnaire during their induction week. Monitoring of responses will continue through the week, lack of engagement will generate further request to students.
03/10/16 to 25/11/16	Initial analysis of completed questionnaires, first round of teaching to this cohort of year 1 students using a tried and trusted "talk and chalk" approach of traditional lecturing to provide that initial view of impact.
28/11 to 02/12/16	Year 1 students who completed the pre-questionnaire will be invited to take it again as a post-questionnaire and encouraged to do so as before.
05/12/16	Analysis and comparison between questionnaire instances will begin. Any significant early findings that need further evidence will be identified. Semi-structured interview guide draft will be modified accordingly, up to 10% of respondents will be randomly selected and invited for a short interview during January 2017.
01/2017	Semi-structured interviews to take place and data transcribed verbatim.
02 to 09/2017	Further reading and construction of initial stages of final thesis will be carried out and preparation taken for the second round of quantitative data collection with the incoming year 1 students in 2017.
10 to 12/2017	Second round of pre and post-teaching data gathering with analysis and comparisons able to take place during December. Teaching approach uses flipped classroom and dialogic methods. Further interviews will be programmed as above at this stage.
01/2018	Further interviews carried out and transcribed as before.
02 to 03/2018	Data analysis of 2017-18 data as for 2016-17 and also comparisons between the two data sets looking for identifiable changes through quantitative statistical tests and qualitative comparative measures.
04 to 06/2018	Thesis write up, check, production and hand in ready for viva and completion.

Appendix 9 – Experiential Learning Cycle (Kolb, 1984)



Appendix 10 – Supporting SPSS Analyses Tables

Table A10.1a Undergraduate distribution tests for normality in the importance of knowledge category by data collection Cohort 1.

Tests of Normality - Cohort 1

	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Accounting & Finance	.910	27	.023	.868	30	.001
Sales and Marketing	.868	27	.003	.888	30	.004
Human Resource Management	.805	27	.000	.883	30	.003
Project planning	.675	27	.000	.813	30	.000
Design and Production	.622	27	.000	.656	30	.000
Quality Management	.758	27	.000	.760	30	.000
Legal aspects	.841	27	.001	.817	30	.000

Table A10.1b Undergraduate distribution tests for normality in the importance of knowledge category by data collection Cohort 2.

Tests of Normality - Cohort 2

	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Accounting & Finance	.881	71	.000	.854	37	.000
Sales and Marketing	.885	71	.000	.871	37	.001
Human Resource Management	.859	71	.000	.855	37	.000
Project planning	.551	71	.000	.623	37	.000
Design and Production	.498	71	.000	.623	37	.000
Quality Management	.723	71	.000	.693	37	.000
Legal aspects	.865	71	.000	.821	37	.000

Table A10.2a Undergraduate distribution tests for normality in the importance of skills category by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Give effective presentations	.785	27	.000	.774	30	.000
Produce quality reports	.718	27	.000	.702	30	.000
Be creative	.758	27	.000	.673	30	.000
Solve problems	.547	27	.000	.424	30	.000
Formulate good questions	.826	27	.000	.694	30	.000
Work effectively in a team	.752	27	.000	.596	30	.000
Design and produce products/services	.794	27	.000	.714	30	.000
Communicate effectively	.711	27	.000	.627	30	.000
Use discussion to investigate an issue	.809	27	.000	.750	30	.000

Table A10.2b Undergraduate distribution tests for normality in the importance of skills category by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-WilkPre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Give effective presentations	.814	71	.000	.808	37	.000
Produce quality reports	.665	71	.000	.692	37	.000
Be creative	.684	71	.000	.753	37	.000
Solve problems	.391	71	.000	.569	37	.000
Formulate good questions	.759	71	.000	.771	37	.000
Work effectively in a team	.658	71	.000	.684	37	.000
Design and produce products/services	.678	71	.000	.764	37	.000
Communicate effectively	.663	71	.000	.720	37	.000
Use discussion to investigate an issue	.767	71	.000	.756	37	.000

Table A10.3 Undergraduate distribution tests for normality in the importance of improvement category by data collection Cohorts 1 & 2.

Tests of Normality - Cohorts 1 & 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
IMPROV_Cohort 1	.576	27	.000	.726	30	.000
IMPROV_Cohort 2	.597	71	.000	.684	37	.000

Table A10.4a Undergraduate distribution tests for normality in self-esteem by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem solving	.852	27	.001	.698	30	.000
Getting resources	.803	27	.000	.874	30	.002
Achieving aims/goals	.858	27	.002	.792	30	.000
Deal with unexpected events	.819	27	.000	.832	30	.000
Resourcefulness	.803	27	.000	.791	30	.000
Relying on oneself	.883	27	.006	.856	30	.001
Investing the approriate effort	.635	27	.000	.617	30	.000
Sticking to my plans	.790	27	.000	.911	30	.015
Being calm under stress	.859	27	.002	.781	30	.000
Generating solutions to problems	.850	27	.001	.804	30	.000
Coping with uncertainty	.753	27	.000	.873	30	.002
Acceptance of challenges	.905	27	.017	.829	30	.000
Thinking around a problem	.735	27	.000	.811	30	.000
Making sensible judgments	.837	27	.001	.664	30	.000
Sticking to my plans 2	.870	27	.003	.909	30	.014

Table A10.4b Undergraduate distribution tests for normality in self-esteem by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-WilkPre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem solving	.864	71	.000	.833	37	.000
Getting resources	.840	71	.000	.866	37	.000
Achieving aims/goals	.867	71	.000	.750	37	.000
Deal with unexpected events	.849	71	.000	.860	37	.000
Resourcefulness	.857	71	.000	.843	37	.000
Relying on oneself	.888	71	.000	.875	37	.001
Investing the approriate effort	.774	71	.000	.768	37	.000
Sticking to my plans	.878	71	.000	.895	37	.002
Being calm under stress	.804	71	.000	.789	37	.000
Generating solutions to problems	.860	71	.000	.816	37	.000
Coping with uncertainty	.806	71	.000	.808	37	.000
Acceptance of challenges	.867	71	.000	.803	37	.000
Thinking around a problem	.799	71	.000	.688	37	.000
Making sensible judgments	.837	71	.000	.857	37	.000
Sticking to my plans 2	.887	71	.000	.907	37	.005

Table A10.5a Undergraduate distribution tests for normality in self-efficacy by data collection Cohort 1.

Tests of Normality - Cohort 1	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Finish reports or assignments on time	.838	27	.001	.880	30	.003
Concentrate on technical engineering subjects	.858	27	.002	.845	30	.000
Take class notes that will be useful in technical or engineering projects	.790	27	.000	.859	30	.001
Use the library and search engines for engineering research	.813	27	.000	.896	30	.007
Plan and organise your workload and technical study space	.888	27	.007	.866	30	.001
Remember 'Engineering Design' lecture content	.904	27	.017	.886	30	.004
Remember 'Engineering Design' practical session outputs	.891	27	.008	.868	30	.001
Motivate yourself to study engineering	.868	27	.003	.852	30	.001
Take part in class based engineering or technical discussions	.895	27	.010	.842	30	.000
Review instructions and estimate how long it will take to complete an engineering task	.853	27	.001	.866	30	.001
Design and construct an experiment that maintains precisely specified conditions	.705	27	.000	.859	30	.001
Lead a technical team to develop a new product to a successful result	.916	27	.032	.885	30	.004
Document technical procedures so that someone else could use them to produce the same result	.860	27	.002	.872	30	.002
Write a clear and concise engineering project plan	.910	27	.023	.860	30	.001

Table A10.5b Undergraduate distribution tests for normality in self-efficacy by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Finish reports or assignments on time	.846	71	.000	.811	37	.000
Concentrate on technical engineering subjects	.780	71	.000	.829	37	.000
Take class notes that will be useful in technical or engineering projects	.870	71	.000	.858	37	.000
Use the library and search engines for engineering research	.849	71	.000	.855	37	.000
Plan and organise your workload and technical study space	.873	71	.000	.859	37	.000
Remember 'Engineering Design' lecture content	.183	71	.000	.866	37	.000
Remember 'Engineering Design' practical session outputs	.822	71	.000	.850	37	.000
Motivate yourself to study engineering	.795	71	.000	.842	37	.000
Take part in class based engineering or technical discussions	.857	71	.000	.780	37	.000
Review instructions and estimate how long it will take to complete an engineering task	.851	71	.000	.847	37	.000
Design and construct an experiment that maintains precisely specified conditions	.857	71	.000	.838	37	.000
Lead a technical team to develop a new product to a successful result	.892	71	.000	.874	37	.001
Document technical procedures so that someone else could use them to produce the same result	.790	71	.000	.699	37	.000
Write a clear and concise engineering project plan	.863	71	.000	.839	37	.000

Table A10.6a Undergraduate distribution tests for normality for learning preference by data collection at Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	.773	27	.000	.786	30	.000
If I am going somewhere new and need directions I usually	.370	27	.000	.616	30	.000
If I am cooking a new dish I generally	.427	27	.000	.665	30	.000
If I am teaching someone something new I tend to	.780	27	.000	.754	30	.000
In general conversation I would tend to say	.809	27	.000	.811	30	.000
During my free time I would rather	.476	27	.000	.652	30	.000
If I were choosing a holiday I would prefer to	.809	27	.000	.794	30	.000
If I were out shopping for clothes I would tend to	.614	27	.000	.526	30	.000
When I concentrate, I most often	.813	27	.000	.806	30	.000
When I am learning a new skill I feel most comfortable when	.773	27	.000	.762	30	.000

Table A10.6b Undergraduate distribution tests for normality for learning preference by data collection at Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	.771	71	.000	.743	37	.000
If I am going somewhere new and need directions I usually	.572	71	.000	.623	37	.000
If I am cooking a new dish I generally	.662	71	.000	.678	37	.000
If I am teaching someone something new I tend to	.726	71	.000	.682	37	.000
In general conversation I would tend to say	.789	71	.000	.699	37	.000
During my free time I would rather	.756	71	.000	.784	37	.000
If I were choosing a holiday I would prefer to	.785	71	.000	.791	37	.000
If I were out shopping for clothes I would tend to	.549	71	.000	.488	37	.000
When I concentrate, I most often	.806	71	.000	.804	37	.000
When I am learning a new skill I feel most comfortable when	.762	71	.000	.690	37	.000

Table A10.7a Undergraduate responses of the importance of skills and of the opportunity to improve split by data collection Cohort 1.

Importance of Skills	Data Set	Mean	Std. Dev	Skewness	Kurtosis
Give effective presentations	Pre	4.00	.707	-.565	.919
	Post	4.00	.866	-1.536	3.935
Produce quality reports	Pre	4.45	.564	-.368	-.855
	Post	4.27	.876	-1.770	4.826
Be creative	Pre	4.33	.645	-.440	-.601
	Post	4.33	.816	-2.173	7.706
Solve problems	Pre	4.79	.485	-2.310	5.036
	Post	4.67	.777	-3.573	15.541
Formulate good questions	Pre	4.21	.820	-.785	.046
	Post	4.09	.765	-1.942	7.658
Work effectively in a team	Pre	4.42	.663	-.733	-.446
	Post	4.42	.792	-2.550	10.112
Design and produce products/services	Pre	4.18	.846	-1.027	.891
	Post	4.30	.883	-1.816	4.843
Communicate effectively	Pre	4.45	.754	-1.467	2.233
	Post	4.42	.830	-2.359	8.120
Use discussion to investigate an issue	Pre	4.15	.712	-.782	1.364
	Post	4.12	.820	-1.682	5.505
Opportunity to Improve	Pre	4.61	.609	-1.316	.815
	Post	4.39	.704	-1.312	2.690

Table 10.7b Undergraduate responses of the importance of skills and of the opportunity to improve split by data collection Cohort 2.

Importance of Skills	Data Set	Mean	Std. Dev	Skewness	Kurtosis
Give effective presentations	Pre	4.08	.833	-.854	1.093
	Post	4.04	.699	-.054	-.878
Produce quality reports	Pre	4.36	.796	-1.563	3.377
	Post	4.48	.614	-.747	-.366
Be creative	Pre	4.45	.793	-1.683	3.499
	Post	4.40	.756	-1.122	.786
Solve problems	Pre	4.76	.565	-3.783	20.953
	Post	4.70	.580	-1.828	2.407
Formulate good questions	Pre	4.19	.729	-1.185	3.420
	Post	4.30	.763	-.863	.271
Work effectively in a team	Pre	4.49	.689	-1.854	6.085
	Post	4.50	.614	-.825	-.260
Design and produce products/services	Pre	4.44	.748	-1.740	4.583
	Post	4.30	.707	-.505	-.845
Communicate effectively	Pre	4.41	.802	-1.931	5.485
	Post	4.42	.642	-.654	-.507
Use discussion to investigate an issue	Pre	4.26	.758	-1.111	2.406
	Post	4.22	.648	-.712	1.636
Opportunity to Improve	Pre	4.59	.603	-1.514	2.917
	Post	4.58	.577	-1.032	.133

Table A10.8a Undergraduate responses of their confidence in their current abilities (Self-Esteem) split by data collection Cohort 1.

Self-Esteem	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Problem solving	Pre	3.64	.994	-.809	.383
	Post	3.79	.781	-1.695	4.713
Getting resources	Pre	3.33	.816	-.706	.919
	Post	3.55	.905	-.548	.806
Achieving aims/goals	Pre	3.45	1.148	-.343	-.966
	Post	3.67	.957	-1.306	2.221
Deal with unexpected events	Pre	3.55	.833	-1.018	1.718
	Post	3.70	.728	.030	-.248
Resourcefulness	Pre	3.27	.801	-.548	.986
	Post	3.64	.699	-.522	.364
Relying on oneself	Pre	2.48	.939	.046	-.782
	Post	3.30	.847	.011	-.609
Investing the appropriate effort	Pre	3.91	.765	-2.071	6.817
	Post	4.00	.559	-1.143	5.190
Sticking to my plans	Pre	2.82	.683	.244	-.750
	Post	2.94	1.029	.127	-.536
Being calm under stress	Pre	3.52	1.202	-.785	-.207
	Post	3.61	1.197	-1.139	.638
Generating solutions to problems	Pre	3.39	.864	-.580	.737
	Post	3.61	.704	-.401	.184
Coping with uncertainty	Pre	3.24	.830	-.844	.043
	Post	3.58	.867	-.248	-.455
Acceptance of challenges	Pre	3.12	1.111	-.398	-.720
	Post	3.18	1.074	.260	-1.274
Thinking around a problem	Pre	3.55	.833	-1.363	1.804
	Post	3.79	.696	-.277	.283
Making sensible judgments	Pre	3.67	.924	-.777	1.026
	Post	4.06	.496	.153	1.479
Sticking to my plans 2	Pre	2.94	.998	.328	.255
	Post	3.18	1.014	-.196	-.027

Table A10.8b Undergraduate responses of their confidence in their current abilities (Self-Esteem) split by data collection Cohort 2.

Self-Esteem	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Problem solving	Pre	3.77	.794	-.243	-.305
	Post	3.82	.774	-.222	-.257
Getting resources	Pre	3.46	.737	-.102	-.273
	Post	3.50	.789	-.130	-.328
Achieving aims/goals	Pre	3.55	.977	-.556	-.219
	Post	3.46	.930	-.908	.507
Deal with unexpected events	Pre	3.70	.841	-.425	.312
	Post	3.72	.730	-.164	-.093
Resourcefulness	Pre	3.62	.773	.027	-.398
	Post	3.64	.776	-.354	-.079
Relying on oneself	Pre	3.07	.863	.193	-.449
	Post	3.16	.912	-.161	-.674
Investing the appropriate effort	Pre	4.04	.686	-.485	.593
	Post	4.08	.695	-.867	1.892
Sticking to my plans	Pre	2.91	.920	.179	-.606
	Post	2.94	.843	-.097	-.014
Being calm under stress	Pre	3.84	.833	-.532	-.058
	Post	3.70	.707	-.577	.484
Generating solutions to problems	Pre	3.58	.807	-.127	-.402
	Post	3.70	.707	-.577	.484
Coping with uncertainty	Pre	3.56	.781	-.769	1.420
	Post	3.68	.794	-1.135	2.052
Acceptance of challenges	Pre	3.43	.912	-.070	-.808
	Post	3.29	1.000	-.614	-.636
Thinking around a problem	Pre	3.88	.736	-.501	.387
	Post	3.76	.693	-1.196	1.668
Making sensible judgments	Pre	3.77	.780	-.436	.809
	Post	3.70	.909	-.713	.605
Sticking to my plans 2	Pre	3.16	.886	.084	-.552
	Post	3.34	.939	-.130	-.310

Table A10.9a Undergraduate responses of their confidence in their future abilities (Self-Efficacy) split by data collection Cohort 1.

Self-Efficacy Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Finish reports or assignments on time	Pre	3.58	1.226	-.837	-.187
	Post	3.48	1.121	-.384	-.800
Concentrate on technical engineering subjects	Pre	3.64	1.113	-.801	.229
	Post	3.94	.864	-.498	-.247
Take class notes that will be useful in technical or engineering projects	Pre	3.45	1.092	-.566	-.746
	Post	3.70	.847	-.339	-.263
Use the library and search engines for engineering research	Pre	3.79	.960	-.672	.764
	Post	3.55	1.034	-.400	-.228
Plan and organise your workload and technical study space	Pre	3.39	1.088	-.563	-.256
	Post	3.70	.810	-.127	-.343
Remember 'Engineering Design' lecture content	Pre	3.36	1.141	-.381	-.606
	Post	3.15	1.395	-.287	-1.185
Remember 'Engineering Design' practical session outputs	Pre	3.55	1.092	-.659	.121
	Post	3.52	1.029	-.636	.718
Motivate yourself to study engineering	Pre	3.70	1.015	-.671	.247
	Post	3.70	.951	-.492	-.529
Take part in class based engineering or technical discussions	Pre	3.36	1.084	-.173	-.108
	Post	3.70	1.015	-.862	.415
Review instructions and estimate how long it will take to complete an engineering task	Pre	3.27	1.153	-.705	-.205
	Post	3.55	1.003	-.726	.934
Design and construct an experiment that maintains precisely specified conditions	Pre	3.42	1.032	-1.329	.843
	Post	3.58	1.119	-.914	.650
Lead a technical team to develop a new product to a successful result	Pre	3.06	1.171	-.248	-.698
	Post	3.42	1.173	-.671	-.267
Document technical procedures so that someone else could use them to produce the same result	Pre	3.00	1.146	-.133	-1.071
	Post	3.67	.957	-.623	.605
Write a clear and concise engineering project plan	Pre	2.94	1.171	.124	-.968
	Post	3.52	1.121	-.748	-.158

Table A10.9b Undergraduate responses of their confidence in their future abilities (Self-Efficacy) split by data collection Cohort 2.

Self-Efficacy Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Finish reports or assignments on time	Pre	3.82	.889	-.807	1.028
	Post	3.84	.997	-1.081	1.246
Concentrate on technical engineering subjects	Pre	3.96	.698	-.341	.188
	Post	3.88	.746	-.107	-.467
Take class notes that will be useful in technical or engineering projects	Pre	3.76	.940	-.651	.369
	Post	3.86	.833	-.389	-.271
Use the library and search engines for engineering research	Pre	3.96	.847	-.823	.999
	Post	3.90	.863	-.397	-.449
Plan and organise your workload and technical study space	Pre	3.62	.881	-.382	-.027
	Post	3.64	.898	-.264	-.587
Remember 'Engineering Design' lecture content	Pre	4.40	5.350	9.145	85.686
	Post	3.30	1.015	-.524	-.103
Remember 'Engineering Design' practical session outputs	Pre	3.96	.718	-.307	-.034
	Post	3.67	.899	-.548	.519
Motivate yourself to study engineering	Pre	4.19	.777	-1.078	2.249
	Post	3.94	.793	-.147	-.773
Take part in class based engineering or technical discussions	Pre	3.80	.962	-.901	.909
	Post	3.78	.790	-.875	2.147
Review instructions and estimate how long it will take to complete an engineering task	Pre	3.68	.791	-.190	-.313
	Post	3.70	.814	-.567	1.304
Design and construct an experiment that maintains precisely specified conditions	Pre	3.73	.804	-.270	.395
	Post	3.76	.716	-.302	.155
Lead a technical team to develop a new product to a successful result	Pre	3.57	.937	-.198	-.430
	Post	3.60	.969	-.084	-.921
Document technical procedures so that someone else could use them to produce the same result	Pre	3.69	.856	-.775	1.062
	Post	3.64	.749	-1.411	2.622
Write a clear and concise engineering project plan	Pre	3.64	.878	-.352	-.011
	Post	3.65	.879	-.970	1.916

Table A10.10a Undergraduate responses of their preference of learning style split by data collection at Cohort 1.

	Data Set	Mean Statistic	Std. Dev. Statistic	Skewness Statistic	Kurtosis Statistic
When I operate new equipment I generally	Pre	2.07	.868	-.134	-1.692
When I operate new equipment I generally	Post	2.06	.864	-.121	-1.675
If I am going somewhere new and need directions I usually	Pre	1.21	.600	2.675	5.751
If I am going somewhere new and need directions I usually	Post	1.55	.833	1.058	-.679
If I am cooking a new dish I generally	Pre	1.38	.793	1.681	.877
If I am cooking a new dish I generally	Post	1.91	.980	.191	-2.018
If I am teaching someone something new I tend to	Pre	2.29	.643	-.342	-.585
If I am teaching someone something new I tend to	Post	2.45	.666	-.839	-.321
In general conversation I would tend to say	Pre	1.97	.706	.045	-.877
In general conversation I would tend to say	Post	1.97	.728	.047	-1.028
During my free time I would rather	Pre	2.22	.420	1.429	.039
During my free time I would rather	Post	2.13	.492	.325	1.186
If I were choosing a holiday I would prefer to	Pre	2.13	.718	-.198	-.954
If I were choosing a holiday I would prefer to	Post	2.09	.818	-.180	-1.475
If I were out shopping for clothes I would tend to	Pre	2.16	.987	-.332	-1.980
If I were out shopping for clothes I would tend to	Post	2.58	.830	-1.476	.187
When I concentrate, I most often	Pre	2.00	.730	.000	-1.034
When I concentrate, I most often	Post	2.06	.704	-.085	-.874
When I am learning a new skill I feel most comfortable when	Pre	2.03	.850	-.066	-1.633
When I am learning a new skill I feel most comfortable when	Post	2.03	.883	-.061	-1.754

Table A10.10b Undergraduate responses of their preference of learning style split by data collection at Cohort 2.

	Data Set	Mean Statistic	Std. Dev. Statistic	Skewness Statistic	Kurtosis Statistic
When I operate new equipment I generally	Pre	2.13	.862	-.247	-1.622
When I operate new equipment I generally	Post	2.11	.895	-.231	-1.744
If I am going somewhere new and need directions I usually	Pre	1.40	.681	1.467	.759
If I am going somewhere new and need directions I usually	Post	1.37	.636	1.540	1.240
If I am cooking a new dish I generally	Pre	1.73	.895	.575	-1.517
If I am cooking a new dish I generally	Post	1.76	.938	.508	-1.707
If I am teaching someone something new I tend to	Pre	2.42	.559	-.251	-.883
If I am teaching someone something new I tend to	Post	2.52	.580	-.735	-.414
In general conversation I would tend to say	Pre	1.88	.819	.231	-1.471
In general conversation I would tend to say	Post	2.08	.922	-.163	-1.843
During my free time I would rather	Pre	2.14	.591	-.042	-.204
During my free time I would rather	Post	2.15	.618	-.095	-.347
If I were choosing a holiday I would prefer to	Pre	2.21	.727	-.348	-1.032
If I were choosing a holiday I would prefer to	Post	1.80	.782	.373	-1.258
If I were out shopping for clothes I would tend to	Pre	2.52	.848	-1.226	-.464
If I were out shopping for clothes I would tend to	Post	2.54	.813	-1.319	-.128
When I concentrate, I most often	Pre	2.10	.731	-.156	-1.096
When I concentrate, I most often	Post	2.04	.781	-.071	-1.339
When I am learning a new skill I feel most comfortable when	Pre	2.32	.801	-.644	-1.140
When I am learning a new skill I feel most comfortable when	Post	2.42	.785	-.912	-.740

Table A10.11a Normality tests UG Cohort 1 of the importance of existing knowledge by gender.

Knowledge Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Accounting and Finance	Pre Post	.020 .003	.056 .000
Sales and Marketing	Pre Post	.006 .030	.000 .000
Human Resource Management	Pre Post	.000 .005	.178 .099
Project Planning	Pre Post	.000 .001	.004 .001
Design and Production	Pre Post	.000 .000	.000 .001
Quality Management	Pre Post	.000 .000	.027 .001
Legal Aspects	Pre Post	.001 .001	.067 .006

Table A10.11b Normality tests UG Cohort 2 of the importance of existing knowledge by gender.

Knowledge Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Accounting and Finance	Pre Post	.000 .000	.156 .609
Sales and Marketing	Pre Post	.000 .000	.002 .099
Human Resource Management	Pre Post	.000 .001	.037 .001
Project Planning	Pre Post	.000 .000	.000 .001
Design and Production	Pre Post	.000 .000	.000 .001
Quality Management	Pre Post	.000 .000	.006 .086
Legal Aspects	Pre Post	.000 .000	.324 .294

Table A10.12a Normality tests UG Cohort 1 of the importance of skills in engineers and of the opportunity to improve by gender.

Skill Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Give effective presentations	Pre Post	.000 .000	.408 .000
Produce quality reports	Pre Post	.000 .000	.004 .086
Be creative	Pre Post	.000 .000	.027 .001
Solve problems	Pre Post	.000 .000	Nil .001
Formulate good questions	Pre Post	.000 .000	.036 .000
Work effectively in a team	Pre Post	.000 .000	.018 .001
Design & produce products/services	Pre Post	.000 .000	.025 .001
Communicate effectively	Pre Post	.000 .000	.027 .001
Use discussion to investigate issues	Pre Post	.000 .000	.015 .099
Opportunity to Improve	Pre Post	.000 .000	.000 .001

Table A10.12b Normality tests UG Cohort 2 of the importance of skills in engineers and of the opportunity to improve by gender.

Skill Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Give effective presentations	Pre Post	.000 .000	.001 .001
Produce quality reports	Pre Post	.000 .000	.000 .001
Be creative	Pre Post	.000 .000	.000 .062
Solve problems	Pre Post	.000 .000	.000 .020
Formulate good questions	Pre Post	.000 .000	.001 .086
Work effectively in a team	Pre Post	.000 .000	.000 .001
Design & produce products/services	Pre Post	.000 .000	.000 .000
Communicate effectively	Pre Post	.000 .000	.000 .001
Use discussion to investigate issues	Pre Post	.000 .000	.001 .099
Opportunity to Improve	Pre Post	.000 .000	.000 .086

Table A10.13a Normality tests UG Cohort 1 responses of their self-esteem by gender.

Self-Esteem Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Problem solving	Pre Post	.001 .000	.036 .456
Getting resources	Pre Post	.000 .002	.246 .237
Achieving aims/goals	Pre Post	.001 .000	.516 .307
Deal with unexpected events	Pre Post	.001 .000	.007 .001
Resourcefulness	Pre Post	.002 .000	.015 .144
Relying on oneself	Pre Post	.009 .000	.408 .482
Investing the appropriate effort	Pre Post	.000 .000	.000 .024
Sticking to my plans	Pre Post	.000 .009	.001 .429
Being calm under stress	Pre Post	.001 .000	.319 .106
Generating solutions to problems	Pre Post	.005 .000	.001 .062
Coping with uncertainty	Pre Post	.000 .000	.007 .064
Acceptance of challenges	Pre Post	.003 .000	.324 .012
Thinking around a problem	Pre Post	.000 .000	.001 .609
Making sensible judgments	Pre Post	.001 .000	.283 .099
Sticking to my plans 2	Pre Post	.009 .030	.054 .183

Table A10.13b Normality tests UG Cohort 2 responses of their self-esteem by gender.

Self-Esteem Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Problem solving	Pre Post	.000 .000	.056 .008
Getting resources	Pre Post	.000 .000	.004 .001
Achieving aims/goals	Pre Post	.000 .000	.120 .001
Deal with unexpected events	Pre Post	.000 .000	.037 .086
Resourcefulness	Pre Post	.000 .000	.037 .086
Relying on oneself	Pre Post	.000 .001	.067 .008
Investing the appropriate effort	Pre Post	.000 .000	.000 .262
Sticking to my plans	Pre Post	.000 .000	.324 .000
Being calm under stress	Pre Post	.000 .000	.005 .001
Generating solutions to problems	Pre Post	.000 .000	.056 .001
Coping with uncertainty	Pre Post	.000 .000	.004 .001
Acceptance of challenges	Pre Post	.000 .000	.000 .001
Thinking around a problem	Pre Post	.000 .000	.000 .000
Making sensible judgments	Pre Post	.000 .000	.000 .609
Sticking to my plans 2	Pre Post	.000 .001	.000 .294

Table A10.14a Normality tests UG Cohort 1 responses of their self-efficacy by gender.

Self-Efficacy Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Finish reports or assignments on time	Pre Post	.000 .004	.516 .215
Concentrate on technical engineering subjects	Pre Post	.001 .002	.792 .139
Take class notes that will be useful in technical or engineering projects	Pre Post	.000 .003	.114 .030
Use the library and search engines for engineering research	Pre Post	.003 .023	.283 .062
Plan and organise your workload and technical study space	Pre Post	.002 .001	.792 .062
Remember 'Engineering Design' lecture content	Pre Post	.010 .011	.792 .086
Remember 'Engineering Design' practical session outputs	Pre Post	.002 .003	.792 .091
Motivate yourself to study engineering	Pre Post	.003 .002	.792 .062
Take part in class based engineering or technical discussions	Pre Post	.000 .001	.512 .294
Review instructions and estimate how long it will take to complete an engineering task	Pre Post	.001 .001	.202 .126
Design and construct an experiment that maintains precisely specified conditions	Pre Post	.000 .003	.428 .099
Lead a technical team to develop a new product to a successful result	Pre Post	.027 .008	.557 .107
Document technical procedures so that someone else could use them to produce the same result	Pre Post	.000 .003	.046 .059
Write a clear and concise engineering project plan	Pre Post	.014 .001	.067 .055

Table A10.14b Normality tests UG Cohort 2 responses of their self-efficacy by gender.

Self-Efficacy Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Finish reports or assignments on time	Pre Post	.000 .000	.056 .000
Concentrate on technical engineering subjects	Pre Post	.000 .000	.000 .000
Take class notes that will be useful in technical or engineering projects	Pre Post	.000 .000	.056 .001
Use the library and search engines for engineering research	Pre Post	.000 .000	.000 .006
Plan and organise your workload and technical study space	Pre Post	.000 .000	.324 .099
Remember 'Engineering Design' lecture content	Pre Post	.000 .000	.037 .482
Remember 'Engineering Design' practical session outputs	Pre Post	.000 .000	.037 .006
Motivate yourself to study engineering	Pre Post	.000 .000	.067 .001
Take part in class based engineering or technical discussions	Pre Post	.000 .000	.324 .000
Review instructions and estimate how long it will take to complete an engineering task	Pre Post	.000 .000	.004 .000
Design and construct an experiment that maintains precisely specified conditions	Pre Post	.000 .000	.054 .001
Lead a technical team to develop a new product to a successful result	Pre Post	.000 .001	.366 .609
Document technical procedures so that someone else could use them to produce the same result	Pre Post	.000 .000	.522 .020
Write a clear and concise engineering project plan	Pre Post	.000 .000	.120 .086

Table A10.15a Normality tests UG Cohort 1 for responses of preferred learning style by gender.

Learning Style Category	Data Set	Shapiro-Wilk Sig.	
		M	F
When I operate new equipment I generally	Pre Post	.000 .000	.067 .144
If I am going somewhere new and need directions I usually	Pre Post	.000 .000	.000 .001
If I am cooking a new dish I generally	Pre Post	.000 .000	.000 .000
If I am teaching someone something new I tend to	Pre Post	.000 .000	.000 .086
In general conversation I would tend to say	Pre Post	.000 .000	.000 .086
During my free time I would rather	Pre Post	.000 .000	.000 .001
If I were choosing a holiday I would prefer to	Pre Post	.000 .000	.062 .091
If I were out shopping for clothes I would tend to	Pre Post	.000 .000	.000 .000
When I concentrate, I most often	Pre Post	.001 .000	.056 .000
When I am learning a new skill, I feel most comfortable when	Pre Post	.000 .000	.067 .099

Table A10.15b Normality tests UG Cohort 2 for responses of learning style preferences by gender.

Learning Style Category	Data Set	Shapiro-Wilk Sig.	
		M	F
When I operate new equipment I generally	Pre Post	.000 .000	.018 .062
If I am going somewhere new and need directions I usually	Pre Post	.000 .000	.000 .000
If I am cooking a new dish I generally	Pre Post	.000 .000	.001 .001
If I am teaching someone something new I tend to	Pre Post	.000 .000	.056 .001
In general conversation I would tend to say	Pre Post	.000 .000	.056 .144
During my free time I would rather	Pre Post	.000 .000	.056 .099
If I were choosing a holiday I would prefer to	Pre Post	.000 .000	.000 .062
If I were out shopping for clothes I would tend to	Pre Post	.000 .000	.000 .000
When I concentrate, I most often	Pre Post	.000 .000	.067 .020
When I am learning a new skill, I feel most comfortable when	Pre Post	.000 .000	.056 .001

Table A10.16a Hypothesis tests UG Cohort 1 of gender differences in the importance of existing knowledge.

Knowledge Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Accounting and Finance	.696	.156	Moderately more significant
Sales and Marketing	.522	.183	Moderately more significant
Human Resource Management	.918	.169	Highly more significant
Project planning	.984	.503	Moderately more significant
Design and Production	.636	.531	Slightly more significant
Quality Management	.789	.846	Slightly less significant
Legal aspects	.150	.424	Moderately less significant

Table A10.16b Hypothesis tests UG Cohort 2 of gender differences in the importance of existing knowledge.

Knowledge Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Accounting and Finance	.170	.812	Highly less significant
Sales and Marketing	.582	.179	Moderately more significant
Human Resource Management	.193	.967	Highly less significant
Project planning	.431	.900	Highly less significant
Design and Production	.777	.856	Slightly less significant
Quality Management	1.000	.748	Moderately more significant
Legal aspects	.628	.791	Slightly less significant

Table A10.17a Hypothesis tests UG Cohort 1 of gender differences of the importance of existing skills.

Skill Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Give effective presentations	.470	.450	Virtually unchanged
Produce quality reports	.636	.880	Moderately less significant
Be creative	.789	.476	Moderately more significant
Solve problems	.330	.399	Slightly less significant
Formulate good questions	1.000	.590	Moderately more significant
Work effectively in a team	.636	.747	Slightly less significant
Design & produce products/services	.606	.949	Moderately less significant
Communicate effectively	.665	.682	Virtually unchanged
Use discussion to investigate issues	.789	.914	Moderately less significant

Table A10.17b Hypothesis tests UG Cohort 2 of gender differences in the importance of existing skills.

Skill Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Give effective presentations	.113	.161	Virtually unchanged
Produce quality reports	.231	.748	Highly less significant
Be creative	.356	.440	Slightly less significant
Solve problems	.559	.361	Slightly more significant
Formulate good questions	.493	.878	Moderately less significant
Work effectively in a team	.160	.605	Moderately less significant
Design & produce products/services	.149	.856	Highly less significant
Communicate effectively	.393	.644	Moderately less significant
Use discussion to investigate issues	.514	.727	Slightly less significant

Table A10.18a Hypothesis tests UG Cohort 1 of gender differences in self-esteem.

Self-Esteem Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Problem solving	.150	.352	Slightly less significant
Getting resources	.853	.268	Highly more significant
Achieving aims/goals	.470	.983	Highly less significant
Deal with unexpected events	.420	.813	Moderately less significant
Resourcefulness	.821	.249	Highly more significant
Relying on oneself	.445	.249	Slightly more significant
Investing the appropriate effort	.578	.914	Moderately less significant
Sticking to my plans	.190	.308	Slightly less significant
Being calm under stress	.290	.682	Moderately less significant
Generating solutions to problems	.696	.531	Slightly more significant
Coping with uncertainty	.789	.620	Slightly more significant
Acceptance of challenges	.127	.651	Highly less significant
Thinking around a problem	.726	.531	Slightly more significant
Making sensible judgments	.757	.714	Virtually unchanged
Sticking to my plans 2	.789	.949	Slightly less significant

Table A10.18b Hypothesis tests UG Cohort 2 of gender differences in self-esteem.

Self-Esteem Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Problem solving	.050	.169	Slightly less significant
Getting resources	.440	.748	Moderately less significant
Achieving aims/goals	.851	.727	Slightly more significant
Deal with unexpected events	.055	.922	Very highly less significant
Resourcefulness	.182	.922	Highly less significant
Relying on oneself	.562	.188	Moderately more significant
Investing the appropriate effort	.182	.114	Slightly more significant
Sticking to my plans	.247	.265	Virtually unchanged
Being calm under stress	.905	.566	Moderately more significant
Generating solutions to problems	.362	.605	Moderately less significant
Coping with uncertainty	.745	.528	Slightly more significant
Acceptance of challenges	.121	.567	Moderately less significant
Thinking around a problem	.206	.841	Highly less significant
Making sensible judgments	.504	.605	Slightly less significant
Sticking to my plans 2	.090	.291	Slightly less significant

Table A10.19a Hypothesis tests UG Cohort 1 of gender differences in self-efficacy.

Self-Efficacy Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Finish reports or assignments on time	.098	.880	Very highly less significant
Concentrate on tech engineering subjects	.036	.682	Highly less significant
Take class notes that will be useful in technical or engineering projects	.578	.249	Moderately more significant
Use the library and search engines for engineering research	.522	.109	Moderately more significant
Plan and organise your workload and technical study space	.138	.169	Virtually unchanged
Remember 'Engineering Design' lecture content	.176	.014	Moderately more significant
Remember 'Engineering Design' practical session outputs	.061	.031	Slightly more significant
Motivate yourself to study engineering	.117	.780	Highly less significant
Take part in class based engineering or technical discussions	.204	.651	Moderately less significant
Review instructions and estimate how long it will take to complete an engineering task	.757	.476	Moderately more significant
Design and construct an experiment that maintains precisely specified conditions	.138	.531	Moderately less significant
Lead a technical team to develop a new product to a successful result	.254	.531	Moderately less significant
Document tech procedures so that someone else could use them to produce the same result	.696	.330	Moderately more significant
Write a clear and concise engineering project plan	.550	.352	Moderately more significant

Table A10.19b Hypothesis tests UG Cohort 2 of gender differences in self-efficacy.

Self-Efficacy Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Finish reports or assignments on time	.652	.605	Virtually unchanged
Concentrate on tech engineering subjects	.322	.510	Slightly less significant
Take class notes that will be useful in technical or engineering projects	.220	.074	Moderately more significant
Use the library and search engines for engineering research	.055	.161	Moderately less significant
Plan and organise your workload and technical study space	.771	.605	Slightly more significant
Remember 'Engineering Design' lecture content	.771	.791	Virtually unchanged
Remember 'Engineering Design' practical session outputs	.549	.529	Virtually unchanged
Motivate yourself to study engineering	.293	.198	Slightly less significant
Take part in class based engineering or technical discussions	.851	.791	Slightly more significant
Review instructions and estimate how long it will take to complete an engineering task	.644	.108	Highly more significant
Design and construct an experiment that maintains precisely specified conditions	.400	.198	Moderately more significant
Lead a technical team to develop a new product to a successful result	.669	1.000	Moderately less significant
Document tech procedures so that someone else could use them to produce the same result	.440	.475	Virtually unchanged
Write a clear and concise engineering project plan	.905	.977	Virtually unchanged

Table A10.20a – Non-parametric significance tests (2-tailed)- Knowledge Category

Importance of Knowledge Category	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Accounting and Finance	.655	.499	.685	.441
Sales and Marketing	.046	.126	.033	.132
Human Resource Management	1.000	.977	1.000	.875
Project planning	.059	.796	.049	.850
Design and Production	.317	.315	.351	.618
Quality Management	.046	.835	.033	.618
Legal aspects	.157	.405	.197	.323

Table A10.20b – Non-parametric significance tests (2-tailed)- Skill Category

Importance of Skills and the Opportunity to Improve Categories	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Give effective presentations	.157	.201	.170	.204
Produce quality Reports	.655	1.000	.685	1.000
Be creative	.046	.513	.033	.519
Solve problems	1.000	.439	1.000	.445
Formulate good Questions	.102	.707	.104	.710
Work effectively in a team	.655	.448	.685	.456
Design & produce products/services	.334	.591	.316	.736
Communicate Effectively	.655	.439	.685	.445
Use discussion to investigate issues	.414	.819	.451	.822
Opportunity to Improve	.317	.808	.351	.812

Table A10.20c – Non-parametric significance tests (2-tailed)- Self-Esteem Category

Self Esteem Category	Wilcoxon Signed Rank Test		Paired Sample Tests	
	Cohort 1	Cohort 2	Cohort 1	Cohort 2
Problem solving	.157	.467	.170	.473
Getting resources	.257	.182	.285	.181
Achieving aims/goals	.564	.449	.598	.439
Deal with unexpected events	.414	.217	.451	.302
Resourcefulness	.257	.872	.285	.855
Relying on oneself	.058	.559	.086	.570
Investing the appropriate effort	.785	.290	.763	.303
Sticking to my plans	.705	.663	.598	.710
Being calm under stress	.317	.028	.351	.026
Generating solutions to problems	.480	.695	.516	.700
Coping with uncertainty	.480	.251	.516	.256
Acceptance of challenges	.414	.857	.451	1.000
Thinking around a problem	.785	1.565	.763	.499
Making sensible judgments	.564	.651	.598	.583
Sticking to my plans 2	.257	.034	.279	.031

Table A10.20d – Non-parametric significance tests (2-tailed)- Self-Efficacy Category

Self Efficacy Category	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Finish reports or assignments on time	.317	.725	.351	.736
Concentrate on technical engineering subjects	.705	.695	.598	.700
Take class notes that will be useful in technical or engineering projects	.655	.712	.563	.860
Use the library and search engines for engineering research	.317	.141	.351	.141
Plan and organise your workload and technical study space	.414	.847	.451	.637
Remember 'Engineering Design' lecture content	.792	.003	.850	.175
Remember 'Engineering Design' practical session outputs	.783	.211	.844	.213
Motivate yourself to study engineering	.564	.166	.598	.241
Take part in class based engineering or technical discussions	.102	.294	.104	.445
Review instructions and estimate how long it will take to complete an engineering task	.317	.975	.351	.878
Design and construct an experiment that maintains precisely specified conditions	.564	.303	.598	.309
Lead a technical team to develop a new product to a successful result	1.000	.392	1.000	.361
Document technical procedures so that someone else could use them to produce the same result	.157	.567	.170	.570
Write a clear and concise engineering project plan	.564	.622	.598	.553

Table A10.20e – Non-parametric significance tests (2-tailed)- Learning Style Category

Learning Style Preference Category	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
When I operate new equipment I generally	.157	.166	.172	.165
If I am going somewhere new and need directions I usually	.317	.290	.351	.302
If I am cooking a new dish I generally	.317	.015	.351	.013
If I am teaching someone something new I tend to	.157	.142	.172	.146
In general conversation I would tend to say	.180	.442	.200	.578
During my free time I would rather	.317	.467	.356	.474
If I were choosing a holiday I would prefer to	.257	.001	.289	.000
If I were out shopping for clothes I would tend to	.083	.566	.078	.660
When I concentrate, I most often	1.000	.098	1.000	.095
When I am learning a new skill I feel most comfortable when	.655	.830	.689	1.000

Table A10.21a Hypothesis tests UG Cohort 1 of gender differences in preferred learning style.

Learning Style Category Item	Mann-Whitney U		Tendency
	Pre	Post	
When I operate new equipment I generally	.872	.846	Virtually unchanged
If I am going somewhere new and need directions I usually	1.000	.780	Moderately less significant
If I am cooking a new dish I generally	.749	.169	Highly more significant
If I am teaching someone something new I tend to	.004	.531	Highly less significant
In general conversation I would tend to say	.695	.352	Moderately more significant
During my free time I would rather	.237	.069	Moderately more significant
If I were choosing a holiday I would prefer to	.341	.189	Slightly more significant
If I were out shopping for clothes I would tend to	.041	.288	Moderately less significant
When I concentrate, I most often	.317	.424	Slightly less significant
When I am learning a new skill I feel most comfortable when	.765	.590	Moderately more significant

Table A10.21b Hypothesis tests UG Cohort 2 of gender differences in preferred learning style.

Learning Style Category Item	Mann-Whitney U		Tendency
	Pre	Post	
When I operate new equipment I generally	.667	.448	Moderately more significant
If I am going somewhere new and need directions I usually	.860	.510	Moderately more significant
If I am cooking a new dish I generally	.429	.791	Moderately less significant
If I am teaching someone something new I tend to	.473	.944	Moderately less significant
In general conversation I would tend to say	.689	.727	Virtually unchanged
During my free time I would rather	.566	.269	Moderately more significant
If I were choosing a holiday I would prefer to	.095	.878	Very Highly less significant
If I were out shopping for clothes I would tend to	.985	.475	Moderately more significant
When I concentrate, I most often	.380	.208	Slightly more significant
When I am learning a new skill I feel most comfortable when	.649	.706	Virtually unchanged

Table A10.22 Hypothesis tests UG Cohort 2 of teaching style differences in the importance of existing knowledge.

Knowledge Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Accounting and Finance	.229	.757	Highly less significant
Sales and Marketing	.628	.285	Moderately more significant
Human Resource Management	.687	.367	Moderately more significant
Project planning	.674	.367	Moderately more significant
Design and Production	.502	.819	Moderately less significant
Quality Management	.965	.275	Highly more significant
Legal aspects	.925	.936	Virtually unchanged

Table A10.23 Hypothesis tests UG Cohort 2 of teaching style differences in the importance of skills and the opportunity to improve.

Skill Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Give effective presentations	.533	.889	Moderately less significant
Produce quality reports	.553	.782	Moderately less significant
Be creative	.353	.569	Moderately more significant
Solve problems	.966	.660	Moderately more significant
Formulate good questions	.820	.507	Moderately more significant
Work effectively in a team	.418	.923	Highly less significant
Design & produce products/services	.740	.143	Highly more significant
Communicate effectively	.489	.905	Highly less significant
Use discussion to investigate issues	.668	.843	Moderately less significant
Opportunity to Improve	.668	.718	Slightly less significant

Table A10.24 Hypothesis tests UG Cohort 2 of teaching style differences in self-esteem.

Self-Esteem Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Problem solving	.683	.944	Moderately less significant
Getting resources	.198	.881	Very highly less significant
Achieving aims/goals	.589	1.000	Highly less significant
Deal with unexpected events	.468	.387	Slightly more significant
Resourcefulness	.947	.605	Moderately more significant
Relying on oneself	.367	.318	Virtually unchanged
Investing the appropriate effort	.802	.723	Slightly more significant
Sticking to my plans	.843	.063	Very highly more significant
Being calm under stress	.198	.698	Highly less significant
Generating solutions to problems	.348	.059	Highly more significant
Coping with uncertainty	.362	.677	Moderately less significant
Acceptance of challenges	.571	.859	Moderately less significant
Thinking around a problem	1.000	.967	Virtually unchanged
Making sensible judgments	.607	.574	Virtually unchanged
Sticking to my plans 2	.683	.875	Moderately less significant

Table A10.25 Hypothesis tests UG Cohort 2 of teaching style differences for self-efficacy.

Self-Efficacy Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Finish reports or assignments on time	.912	.571	Moderately more significant
Concentrate on technical engineering subjects	.581	.889	Moderately less significant
Take class notes that will be useful in technical or engineering projects	.180	.123	Slightly more significant
Use the library and search engines for engineering research	.906	.991	Slightly less significant
Plan and organise your workload and technical study space	.782	.795	Virtually unchanged
Remember 'Engineering Design' lecture content	.626	.400	Moderately more significant
Remember 'Engineering Design' practical session outputs	.452	.707	Moderately less significant
Motivate yourself to study engineering	.683	.828	Moderately less significant
Take part in class based engineering or technical discussions	.762	.523	Moderately more significant
Review instructions and estimate how long it will take to complete an engineering task	.484	.667	Moderately less significant
Design and construct an experiment that maintains precisely specified conditions	.390	.794	Moderately less significant
Lead a technical team to develop a new product to a successful result	.823	.681	Moderately more significant
Document technical procedures so that someone else could use them to produce the same result	.664	.791	Slightly less significant
Write a clear and concise engineering project plan	.927	.651	Moderately more significant

Table A10.26 Hypothesis tests UG Cohort 2 of teaching style differences for learning style preference.

Learning Style Preference Category Item	Mann-Whitney U		Tendency
	Pre	Post	
When I operate new equipment I generally	.753	.705	Slightly more significant
If I am going somewhere new and need directions I usually	.120	.967	Very highly less significant
If I am cooking a new dish I generally	.272	.604	Moderately less significant
If I am teaching someone something new I tend to	.491	.474	Virtually unchanged
In general conversation, I would tend to say	.115	.967	Very highly less significant
During my free time, I would rather	.119	.092	Slightly more significant
If I were choosing a holiday I would prefer to	.830	.190	Very highly more significant
If I were out shopping for clothes I would tend to	.192	.266	Moderately less significant
When I concentrate, I most often	.954	.790	Moderately more significant
When I am learning a new skill, I feel most comfortable when	.697	1.000	Moderately less significant

Table A10.27 Undergraduate importance of knowledge – inter-item correlation matrix Cohort 1

Inter-Item Correlation Matrix Pre							
	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.490	.472	.307	.230	.261	.570
Sales and Marketing	.490	1.000	.394	.237	.228	.325	.326
Human Resource	.472	.394	1.000	.477	.363	.334	.389
Project planning	.307	.237	.477	1.000	.696	.628	.274
Design and Production	.230	.228	.363	.696	1.000	.618	.062
Quality Management	.261	.325	.334	.628	.618	1.000	.087
Legal aspects	.570	.326	.389	.274	.062	.087	1.000

Inter-Item Correlation Matrix Post							
	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.335	.551	.058	.029	.397	.334
Sales and Marketing	.335	1.000	.514	.291	.112	.462	.402
Human Resource	.551	.514	1.000	.371	.170	.586	.619
Project planning	.058	.291	.371	1.000	.568	.670	.215
Design and Production	.029	.112	.170	.568	1.000	.518	.172
Quality Management	.397	.462	.586	.670	.518	1.000	.452
Legal aspects	.334	.402	.619	.215	.172	.452	1.000

Table A10.28 Undergraduate importance of knowledge – inter-item correlation matrix Cohort 2

Inter-Item Correlation Matrix Pre

	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.585	.530	.379	.385	.389	.656
Sales and Marketing	.585	1.000	.543	.314	.230	.174	.485
Human Resource	.530	.543	1.000	.400	.383	.364	.462
Project planning	.379	.314	.400	1.000	.824	.655	.399
Design and Production	.385	.230	.383	.824	1.000	.690	.404
Quality Management	.389	.174	.364	.655	.690	1.000	.382
Legal aspects	.656	.485	.462	.399	.404	.382	1.000

Inter-Item Correlation Matrix Post

	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.614	.579	.210	-.059	.097	.610
Sales and Marketing	.614	1.000	.694	.229	.042	.260	.553
Human Resource	.579	.694	1.000	.114	.049	.297	.605
Project planning	.210	.229	.114	1.000	.672	.699	.281
Design and Production	-.059	.042	.049	.672	1.000	.623	.134
Quality Management	.097	.260	.297	.699	.623	1.000	.292
Legal aspects	.610	.553	.605	.281	.134	.292	1.000

Table A10.29 Undergraduate importance of knowledge – Summary item statistics Cohort 1

Summary Item Statistics

Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Pre	.370	.062	.696	.635	11.303	.028	7
Post	.373	.029	.670	.641	23.175	.035	7

Table A10.30 Undergraduate importance of knowledge – Summary item statistics Cohort 2

Summary Item Statistics

Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Pre	.459	.174	.824	.650	4.727	.024	7
Post	.362	-.059	.699	.758	-11.762	.063	7

Table A10.31 Undergraduate importance of knowledge – Item-total statistics Cohort 1

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	24.24	8.877	.608	.469	.748
Sales and Marketing	24.06	10.246	.503	.313	.768
Human Resource Management	24.03	9.468	.601	.379	.748
Project planning	23.03	10.655	.597	.619	.756
Design and Production	22.94	11.371	.477	.557	.776
Quality Management	23.24	10.939	.488	.493	.772
Legal aspects	23.91	9.960	.450	.399	.782
Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	23.52	13.570	.413	.390	.793
Sales and Marketing	23.52	12.633	.516	.321	.775
Human Resource Management	23.39	11.871	.725	.616	.733
Project planning	22.61	13.621	.486	.569	.779
Design and Production	22.30	13.655	.337	.393	.802
Quality Management	22.45	14.881	.767	.670	.739
Legal aspects	22.94	12.059	.539	.419	.773

Table A10.32 Undergraduate importance of knowledge – Item-total statistics Cohort 2

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	24.43	13.642	.684	.561	.819
Sales and Marketing	24.51	14.095	.528	.462	.845
Human Resource Management	24.39	14.375	.612	.412	.830
Project planning	23.43	14.698	.653	.710	.826
Design and Production	23.38	14.822	.637	.725	.828
Quality Management	23.71	14.635	.567	.530	.836
Legal aspects	24.21	13.404	.639	.479	.826

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	24.72	10.981	.551	.559	.771
Sales and Marketing	24.82	10.355	.639	.567	.754
Human Resource Management	24.80	9.714	.618	.620	.759
Project planning	23.86	12.041	.483	.658	.784
Design and Production	23.86	12.776	.287	.540	.812
Quality Management	24.04	11.713	.507	.608	.780
Legal aspects	24.42	10.085	.647	.499	.751

Table A10.33a Undergraduate importance of skills – inter-item correlation matrix t1

Inter-Item Correlation Matrix Pre									
	Give effective pres	Produce quality reports	Be creative	Solve problems	Formulate good questions	Work effectively in a team	Design produce prod/serv	Commun-icate effectively	Use disc' to investigate an issue
Give effective presentations	1.000	.548	.000	.091	.269	.467	.366	.469	.496
Produce quality reports	.548	1.000	-.086	.021	.190	.471	.280	.528	.601
Be creative	.000	-.086	1.000	.433	.453	.170	.458	.321	.227
Solve problems	.091	.021	.433	1.000	.510	.289	.173	.358	.187
Formulate good questions	.269	.190	.453	.510	1.000	.289	.573	.294	.478
Work effectively in a team	.467	.471	.170	.289	.289	1.000	.471	.665	.654
Design and produce	.366	.280	.458	.173	.573	.471	1.000	.307	.471
Communicate effectively	.469	.528	.321	.358	.294	.665	.307	1.000	.508
Use discussion to investigate an issue	.496	.601	.227	.187	.478	.654	.471	.508	1.000

Table A10.33b Undergraduate importance of skills – inter-item correlation matrix t2

Inter-Item Correlation Matrix Post

	Give effective pres	Produce quality reports	Be creative	Solve problems	Formulate good questions	Work effectively in a team	Design produce prod/serv	Commun-icate effectively	Use disc' to investigate an issue
Give effective presentations	1.000	.577	.530	.557	.613	.592	.654	.522	.704
Produce quality reports	.577	1.000	.699	.734	.522	.774	.819	.738	.605
Be creative	.530	.699	1.000	.771	.650	.693	.679	.569	.638
Solve problems	.557	.734	.771	1.000	.631	.846	.743	.807	.654
Formulate good questions	.613	.522	.650	.631	1.000	.760	.559	.626	.729
Work effectively in a team	.592	.774	.693	.846	.760	1.000	.838	.906	.785
Design and produce	.654	.819	.679	.743	.559	.838	1.000	.757	.724
Communicate effectively	.522	.738	.569	.807	.626	.906	.757	1.000	.657
Use discussion to investigate an issue	.704	.605	.638	.654	.729	.785	.724	.657	1.000

Table A10.33c Undergraduate importance of skills – inter-item correlation matrix t3

Inter-Item Correlation Matrix Pre	Give effective pres	Produce quality reports	Be creative	Solve problems	Formulate good questions	Work effectively in a team	Design produce prod/serv	Commun-icate effectively	Use disc' to investigate an issue
Give effective presentations	1.000	.567	.473	.465	.469	.335	.365	.479	.514
Produce quality reports	.567	1.000	.398	.606	.476	.371	.539	.623	.387
Be creative	.473	.398	1.000	.463	.593	.380	.383	.391	.606
Solve problems	.465	.606	.463	1.000	.567	.516	.476	.431	.420
Formulate good questions	.469	.476	.593	.567	1.000	.402	.410	.389	.469
Work effectively in a team	.335	.371	.380	.516	.402	1.000	.522	.423	.462
Design and produce	.365	.539	.383	.476	.410	.522	1.000	.605	.514
Communicate effectively	.479	.623	.391	.431	.389	.423	.605	1.000	.451
Use discussion to investigate an issue	.514	.387	.606	.420	.469	.462	.514	.451	1.000

Table A10.33d Undergraduate importance of skills – inter-item correlation matrix t4

Inter-Item Correlation Matrix Post

	Give effective pres	Produce quality reports	Be creative	Solve problems	Formulate good questions	Work effectively in a team	Design produce prod/serv	Commun-icate effectively	Use disc' to investigate an issue
Give effective presentations	1.000	.436	.242	.132	.210	.384	.389	.511	.386
Produce quality reports	.436	1.000	.220	.160	.281	.335	.230	.368	.299
Be creative	.242	.220	1.000	.408	.594	.275	.505	.244	.322
Solve problems	.132	.160	.408	1.000	.478	.490	.375	.289	.344
Formulate good questions	.210	.281	.594	.478	1.000	.612	.331	.377	.577
Work effectively in a team	.384	.335	.275	.490	.612	1.000	.487	.639	.639
Design and produce	.389	.230	.505	.375	.331	.487	1.000	.384	.429
Communicate effectively	.511	.368	.244	.289	.377	.639	.384	1.000	.704
Use discussion to investigate an issue	.386	.299	.322	.344	.577	.639	.429	.704	1.000

Table A10.34 Undergraduate importance of skills – Summary item statistics

Summary Item Statistics

Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.361	-.086	.665	.751	-7.751	.034	9
Cohort 1 Post	.685	.522	.906	.385	1.737	.010	9
Cohort 1 Pre	.410	.068	.623	.555	9.186	.022	9
Cohort 1 Post	.371	.132	.704	.572	5.320	.019	9

Table A10.35a Undergraduate importance of skills – Item-total statistics Cohort 1

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	35.00	13.938	.509	.417	.825
Produce quality reports	34.55	14.693	.489	.563	.827
Be creative	34.67	14.854	.373	.509	.838
Solve problems	34.21	15.422	.386	.454	.836
Formulate good questions	34.79	13.047	.575	.588	.819
Work effectively in a team	34.58	13.439	.668	.666	.808
Design and produce	34.82	12.778	.600	.580	.816
Communicate effectively	34.55	13.068	.640	.625	.810
Use discussion to investigate an issue	34.85	13.008	.702	.645	.803

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	34.64	32.176	.687	.615	.951
Produce quality reports	34.36	31.051	.805	.749	.945
Be creative	34.30	31.968	.763	.734	.947
Solve problems	33.97	31.655	.848	.814	.943
Formulate good questions	34.55	32.631	.739	.739	.948
Work effectively in a team	34.21	30.922	.923	.936	.939
Design and produce	34.33	30.542	.856	.824	.942
Communicate effectively	34.21	31.360	.820	.855	.944
Use discussion to investigate an issue	34.52	31.570	.807	.739	.945

Table A10.35b Undergraduate importance of skills – Item-total statistics Cohort 2

Item-Total Statistics Pre

	Scale Mean if Item Deleted	Scale Variance if Item	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	40.09	20.396	.648	.487	.860
Produce quality reports	39.80	20.400	.695	.615	.856
Be creative	39.72	20.991	.611	.511	.863
Solve problems	39.39	22.288	.659	.544	.862
Formulate good questions	39.98	21.214	.636	.485	.861
Work effectively in a team	39.65	22.017	.561	.401	.867
Design and produce	39.73	20.962	.648	.521	.860
Communicate effectively	39.75	20.664	.634	.543	.861
Use discussion to investigate an issue	39.89	20.882	.659	.523	.859

Item-Total Statistics Post

	Scale Mean if Item Deleted	Scale Variance if Item	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	39.96	16.126	.491	.400	.847
Produce quality reports	39.52	16.893	.427	.261	.851
Be creative	39.60	15.776	.508	.555	.846
Solve problems	39.29	16.637	.521	.439	.844
Formulate good questions	39.71	15.105	.626	.665	.834
Work effectively in a team	39.48	15.574	.715	.674	.828
Design and produce	39.69	15.624	.581	.474	.838
Communicate effectively	39.56	15.783	.628	.635	.834
Use discussion to investigate an issue	39.77	15.457	.685	.639	.829

Table A10.36a Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 1 part 1

Inter-Item Correlation Matrix – Pre

	Problem solving	Getting resources	Achieving aims/ goals	Deal with unexpected events	Resource-fulness	Relying on oneself	Investing the appropriate effort
Problem solving	1.000	.346	.450	.700	.364	-.006	.407
Getting resources	.346	1.000	.400	.276	.430	.068	-.100
Achieving aims/goals	.450	.400	1.000	.583	.506	-.008	.013
Deal with unexpected events	.700	.276	.583	1.000	.613	.131	.375
Resourcefulness	.364	.430	.506	.613	1.000	.275	.246
Relying on oneself	-.006	.068	-.008	.131	.275	1.000	.281
Investing the appropriate effort	.407	-.100	.013	.375	.246	.281	1.000
Sticking to my plans	-.054	-.112	.069	.180	.036	.142	-.092
Being calm under stress	.397	-.053	-.039	.366	.206	.353	.154
Generating solutions to problems	.536	.473	.255	.474	.472	.335	.387
Coping with uncertainty	.564	.384	.241	.526	.508	.245	.429
Acceptance of challenges	.267	.298	.347	.501	.418	.062	-.207
Thinking around a problem	.323	.322	.484	.504	.566	.211	-.018
Making sensible judgments	.612	.152	.530	.690	.506	.192	.398
Sticking to my plans 2	.009	.102	.161	.116	.412	.199	.238

Table A10.36b Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 1 part 2

Inter-Item Correlation Matrix – Pre								
	Sticking to my plans	Being calm under stress	Generate solutions to problems	Coping with uncertai-nty	Accepta-nce of challeng-es	Thinking around a problem	Making sensible judgments	Sticking to my plans 2
Problem solving	-.054	.397	.536	.564	.267	.323	.612	.009
Getting resources	-.112	-.053	.473	.384	.298	.322	.152	.102
Achieving aims/goals	.069	-.039	.255	.241	.347	.484	.530	.161
Deal with unexpected events	.180	.366	.474	.526	.501	.504	.690	.116
Resourcefulness	.036	.206	.472	.508	.418	.566	.506	.412
Relying on oneself	.142	.353	.335	.245	.062	.211	.192	.199
Investing the appropriate effort	-.092	.154	.387	.429	-.207	-.018	.398	.238
Sticking to my plans	1.000	.003	-.299	-.195	.401	.125	-.099	.488
Being calm under stress	.003	1.000	.370	.247	.326	.241	.244	-.103
Generating solutions to problems	-.299	.370	1.000	.691	.144	.170	.444	-.116
Coping with uncertainty	-.195	.247	.691	1.000	.035	.255	.516	-.095
Acceptance of challenges	.401	.326	.144	.035	1.000	.467	.132	.063
Thinking around a problem	.125	.241	.170	.255	.467	1.000	.203	.191
Making sensible judgments	-.099	.244	.444	.516	.132	.203	1.000	.079
Sticking to my plans 2	.488	-.103	-.116	-.095	.063	.191	.079	1.000

Table A10.37a Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 1 part 1

Inter-Item Correlation Matrix – Post							
	Problem solving	Getting resources	Achieving aims/ goals	Deal with unexpected events	Resource-fulness	Relying on oneself	Investing the appropriate effort
Problem solving	1.000	.434	.237	.433	.198	.195	.358
Getting resources	.434	1.000	.144	.069	.027	-.100	.309
Achieving aims/goals	.237	.144	1.000	.299	.187	.244	.058
Deal with unexpected events	.433	.069	.299	1.000	.452	.559	.077
Resourcefulness	.198	.027	.187	.452	1.000	.614	.160
Relying on oneself	.195	-.100	.244	.559	.614	1.000	.066
Investing the appropriate effort	.358	.309	.058	.077	.160	.066	1.000
Sticking to my plans	.100	.238	-.180	-.234	.273	-.086	.272
Being calm under stress	.209	-.026	.209	-.034	.010	-.125	-.233
Generating solutions to problems	.127	.054	.031	.308	.208	.520	-.079
Coping with uncertainty	.417	.025	.201	.631	.305	.521	.322
Acceptance of challenges	.495	.152	.274	.512	.465	.521	.104
Thinking around a problem	.317	.189	.453	.177	.286	.324	.321
Making sensible judgments	.034	-.146	.175	.225	.516	.475	.225
Sticking to my plans 2	.129	.331	.193	-.135	.273	.152	.276

Table A10.37b Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 1 part 2

Inter-Item Correlation Matrix – Post

	Sticking to my plans	Being calm under stress	Generate solutions to problems	Coping with uncertainty	Acceptance of challenges	Thinking around a problem	Making sensible judgments	Sticking to my plans 2
Problem solving	.100	.209	.127	.417	.495	.317	.034	.129
Getting resources	.238	-.026	.054	.025	.152	.189	-.146	.331
Achieving aims/goals	-.180	.209	.031	.201	.274	.453	.175	.193
Deal with unexpected events	-.234	-.034	.308	.631	.512	.177	.225	-.135
Resourcefulness	.273	.010	.208	.305	.465	.286	.516	.273
Relying on oneself	-.086	-.125	.520	.521	.521	.324	.475	.152
Investing the appropriate effort	.272	-.233	-.079	.322	.104	.321	.225	.276
Sticking to my plans	1.000	-.324	-.250	-.275	.123	.156	.191	.490
Being calm under stress	-.324	1.000	-.153	.075	.130	-.178	-.116	-.145
Generating solutions to problems	-.250	-.153	1.000	.383	.263	.207	.339	.060
Coping with uncertainty	-.275	.075	.383	1.000	.589	.260	.280	-.016
Acceptance of challenges	.123	.130	.263	.589	1.000	.304	.272	.055
Thinking around a problem	.156	-.178	.207	.260	.304	1.000	.581	.056
Making sensible judgments	.191	-.116	.339	.280	.272	.581	1.000	.164
Sticking to my plans 2	.490	-.145	.060	-.016	.055	.056	.164	1.000

Table A10.38a Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 2 part 1

Inter-Item Correlation Matrix – Pre

	Problem solving	Getting resources	Achieving aims/ goals	Deal with unexpected events	Resource -fulness	Relying on oneself	Investing the appropriate effort
Problem solving	1.000	.237	.367	.425	.399	.343	.559
Getting resources	.237	1.000	.345	.269	.375	.195	.180
Achieving aims/goals	.367	.345	1.000	.513	.359	.197	.330
Deal with unexpected events	.425	.269	.513	1.000	.711	.269	.467
Resourcefulness	.399	.375	.359	.711	1.000	.350	.414
Relying on oneself	.343	.195	.197	.269	.350	1.000	.153
Investing the appropriate effort	.559	.180	.330	.467	.414	.153	1.000
Sticking to my plans	.037	.205	.003	.048	.034	.130	.155
Being calm under stress	.088	-.044	.283	.289	.128	-.092	.198
Generating solutions to problems	.249	.211	.287	.376	.492	.307	.212
Coping with uncertainty	.499	.280	.466	.486	.537	.209	.461
Acceptance of challenges	.335	.155	.362	.575	.354	.199	.364
Thinking around a problem	.441	.244	.213	.485	.556	.141	.465
Making sensible judgments	.131	.234	.304	.421	.510	.109	.293
Sticking to my plans 2	.118	.054	.084	.031	.000	.211	.066

Table A10.38b Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 2 part 2

Inter-Item Correlation Matrix – Pre

	Sticking to my plans	Being calm under stress	Generate solutions to problems	Coping with uncertai-nty	Accepta-nce of challeng-es	Thinking around a problem	Making sensible judgments	Sticking to my plans 2
Problem solving	.037	.088	.249	.499	.335	.441	.131	.118
Getting resources	.205	-.044	.211	.280	.155	.244	.234	.054
Achieving aims/goals	.003	.283	.287	.466	.362	.213	.304	.084
Deal with unexpected events	.048	.289	.376	.486	.575	.485	.421	.031
Resourcefulness	.034	.128	.492	.537	.354	.556	.510	.000
Relying on oneself	.130	-.092	.307	.209	.199	.141	.109	.211
Investing the appropriate effort	.155	.198	.212	.461	.364	.465	.293	.066
Sticking to my plans	1.000	-.002	.005	.131	.249	.082	-.057	.534
Being calm under stress	-.002	1.000	.075	.285	.353	.337	.241	-.042
Generating solutions to problems	.005	.075	1.000	.311	.128	.285	.208	-.001
Coping with uncertainty	.131	.285	.311	1.000	.420	.490	.399	.011
Acceptance of challenges	.249	.353	.128	.420	1.000	.421	.206	.112
Thinking around a problem	.082	.337	.285	.490	.421	1.000	.394	.098
Making sensible judgments	-.057	.241	.208	.399	.206	.394	1.000	-.078
Sticking to my plans 2	.534	-.042	-.001	.011	.112	.098	-.078	1.000

Table A10.39a Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 2 part 1

Inter-Item Correlation Matrix – Post

	Problem solving	Getting resources	Achieving aims/ goals	Deal with unexpected events	Resource-fulness	Relying on oneself	Investing the appropriate effort
Problem solving	1.000	.155	.272	.199	.067	.190	.606
Getting resources	.155	1.000	.350	.183	.196	.160	.225
Achieving aims/goals	.272	.350	1.000	.408	.384	.274	.340
Deal with unexpected events	.199	.183	.408	1.000	.634	.327	.329
Resourcefulness	.067	.196	.384	.634	1.000	.554	.371
Relying on oneself	.190	.160	.274	.327	.554	1.000	.369
Investing the appropriate effort	.606	.225	.340	.329	.371	.369	1.000
Sticking to my plans	.415	.207	.016	.148	.138	.322	.368
Being calm under stress	-.152	-.019	.130	.279	.158	.080	.046
Generating solutions to problems	.160	-.170	.095	.072	.199	.113	.385
Coping with uncertainty	.246	-.076	.287	.459	.173	.075	.300
Acceptance of challenges	.089	-.013	.348	.522	.535	.239	.083
Thinking around a problem	.175	-.019	.307	.390	.352	.204	.387
Making sensible judgments	.059	.029	.377	.142	.174	.142	.233
Sticking to my plans 2	.270	.084	.247	.153	.269	.366	.241

Table A10.39b Undergraduate responses for self-esteem – Inter-Item Correlation statistics cohort 2 part 2

Inter-Item Correlation Matrix – Post	Sticking to my plans	Being calm under stress	Generate solutions to problems	Coping with uncertai-nty	Accepta-nce of challeng-es	Thinking around a problem	Making sensible judgments	Sticking to my plans 2
Problem solving	.415	-.152	.160	.246	.089	.175	.059	.270
Getting resources	.207	-.019	-.170	-.076	-.013	-.019	.029	.084
Achieving aims/goals	.016	.130	.095	.287	.348	.307	.377	.247
Deal with unexpected events	.148	.279	.072	.459	.522	.390	.142	.153
Resourcefulness	.138	.158	.199	.173	.535	.352	.174	.269
Relying on oneself	.322	.080	.113	.075	.239	.204	.142	.366
Investing the appropriate effort	.368	.046	.385	.300	.083	.387	.233	.241
Sticking to my plans	1.000	-.101	.187	.046	.101	-.025	-.383	.508
Being calm under stress	-.101	1.000	.191	.334	.426	.262	.170	.042
Generating solutions to problems	.187	.191	1.000	.334	.366	.393	-.059	.137
Coping with uncertainty	.046	.334	.334	1.000	.360	.495	.215	.096
Acceptance of challenges	.101	.426	.366	.360	1.000	.602	.148	.315
Thinking around a problem	-.025	.262	.393	.495	.602	1.000	.394	.151
Making sensible judgments	-.383	.170	-.059	.215	.148	.394	1.000	.016
Sticking to my plans 2	.508	.042	.137	.096	.315	.151	.016	1.000

Table A10.40 Undergraduate self-esteem – Summary item statistics

Summary Item Statistics Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.258	-.299	.700	.999	-2.344	.050	15
Cohort 1 Post	.189	-.324	.631	.956	-1.946	.048	15
Cohort 2 Pre	.257	-.092	.711	.803	-7.751	.030	15
Cohort 2 Post	.220	-.383	.634	1.017	-1.653	.031	15

Table A10.41a Undergraduate responses for self-esteem – Item-Total statistics cohort 1 Pre

Item-Total Statistics – Pre	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	46.24	48.377	.646	.746	.812
Getting resources	46.55	53.068	.384	.607	.829
Achieving aims/goals	46.42	48.877	.505	.615	.822
Deal with unexpected events	46.33	48.229	.811	.825	.804
Resourcefulness	46.61	49.371	.736	.790	.810
Relying on oneself	47.39	53.246	.304	.520	.834
Investing the appropriate effort	45.97	54.218	.310	.644	.832
Sticking to my plans	47.06	56.871	.093	.686	.841
Being calm under stress	46.36	50.989	.342	.557	.835
Generating solutions to problems	46.48	50.633	.563	.710	.818
Coping with uncertainty	46.64	51.051	.553	.708	.819
Acceptance of challenges	46.76	50.502	.415	.677	.828
Thinking around a problem	46.33	51.229	.535	.584	.820
Making sensible judgments	46.21	49.610	.602	.711	.815
Sticking to my plans 2	46.94	54.496	.190	.712	.842

Table A10.41b Undergraduate responses for self-esteem – Item-Total statistics cohort 1 Post

Item-Total Statistics – Post	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	49.79	30.360	.570	.643	.707
Getting resources	50.03	32.405	.258	.471	.737
Achieving aims/goals	49.91	31.023	.369	.600	.725
Deal with unexpected events	49.88	31.485	.473	.744	.717
Resourcefulness	49.94	30.871	.582	.636	.709
Relying on oneself	50.27	30.205	.532	.687	.709
Investing the appropriate effort	49.58	33.564	.309	.538	.732
Sticking to my plans	50.64	34.301	.043	.738	.763
Being calm under stress	49.97	35.593	-.080	.592	.786
Generating solutions to problems	49.97	33.280	.258	.536	.735
Coping with uncertainty	50.00	30.188	.518	.725	.710
Acceptance of challenges	50.39	27.496	.642	.658	.689
Thinking around a problem	49.79	31.735	.466	.715	.718
Making sensible judgments	49.52	33.133	.437	.660	.726
Sticking to my plans 2	50.39	31.809	.266	.627	.738

Table A10.41c Undergraduate responses for self-esteem – Item-Total statistics cohort 2 Pre

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	49.66	38.577	.540	.511	.817
Getting resources	49.99	40.639	.376	.289	.827
Achieving aims/goals	49.85	37.710	.526	.464	.817
Deal with unexpected events	49.69	37.240	.705	.678	.806
Resourcefulness	49.77	37.598	.676	.697	.809
Relying on oneself	50.34	40.112	.348	.274	.829
Investing the appropriate effort	49.38	39.354	.556	.445	.817
Sticking to my plans	50.54	41.461	.200	.432	.840
Being calm under stress	49.52	41.346	.261	.303	.834
Generating solutions to problems	49.84	39.904	.395	.296	.826
Coping with uncertainty	49.82	38.175	.649	.513	.811
Acceptance of challenges	49.98	37.674	.549	.475	.816
Thinking around a problem	49.53	38.624	.596	.521	.814
Making sensible judgments	49.64	39.930	.411	.369	.825
Sticking to my plans 2	50.25	41.959	.160	.371	.842

Table A10.41d Undergraduate responses for self-esteem – Item-Total statistics cohort 2 Post

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	50.00	35.489	.370	.555	.796
Getting resources	50.35	37.127	.177	.288	.810
Achieving aims/goals	50.33	33.333	.534	.442	.784
Deal with unexpected events	50.10	33.968	.587	.626	.782
Resourcefulness	50.17	33.759	.595	.685	.781
Relying on oneself	50.67	33.631	.473	.426	.789
Investing the appropriate effort	49.77	34.138	.585	.734	.782
Sticking to my plans	50.92	36.163	.261	.605	.805
Being calm under stress	50.13	36.878	.246	.359	.804
Generating solutions to problems	50.13	36.324	.313	.487	.800
Coping with uncertainty	50.10	35.329	.441	.472	.792
Acceptance of challenges	50.54	32.211	.558	.743	.781
Thinking around a problem	50.08	34.461	.560	.618	.784
Making sensible judgments	50.15	36.297	.211	.489	.810
Sticking to my plans 2	50.52	34.085	.404	.415	.795

Table A10.42a Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 1 part 1

Inter-Item Correlation Matrix – Pre

	Finish reports etc. on time	Concentrate on tech Eng subjects	Take useful class notes	Use library or search engines for Eng research	Plan and organise your work load and tech study space	Remember 'Engineering Design' lecture content	Remember 'Engineering Design' practical content
Finish reports or assignments on time	1.000	.823	.569	.532	.668	.539	.575
Concentrate on technical engineering subjects	.823	1.000	.603	.481	.690	.649	.785
Take class notes that will be useful in technical or engineering projects	.569	.603	1.000	.393	.739	.591	.467
Use the library and search engines for engineering research	.532	.481	.393	1.000	.501	.329	.382
Plan and organise your workload/technical study space	.668	.690	.739	.501	1.000	.762	.629
Remember 'Engineering Design' lecture content	.539	.649	.591	.329	.762	1.000	.764
Remember 'Engineering Design' practical session outputs	.575	.785	.467	.382	.629	.764	1.000
Motivate yourself to study engineering	.521	.591	.523	.541	.677	.476	.577
Take part in class based engineering or technical discussions	.543	.579	.331	.556	.484	.395	.566
Review instructions and estimate how long it will take to complete an engineering task	.726	.664	.420	.562	.609	.564	.498
Design and construct an experiment that maintains precisely specified conditions	.864	.737	.461	.567	.654	.529	.592
Lead a technical team to develop a new product to a successful result	.585	.521	.393	.456	.496	.521	.511
Document technical procedures so that someone else could use them to produce the same result	.556	.441	.350	.511	.451	.287	.275
Write a clear and concise engineering project plan	.591	.606	.438	.516	.534	.391	.491

Table A10.42b Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 1 part 2

Inter-Item Correlation Matrix – Pre

	Motivate yourself to study Eng.	Take part in class based Eng or Technical discussions	Review and estimate how long to complete an Eng task.	Design and construct an experiment for specified conditions	Lead a tech team to develop a new product successfully	Document technical procedures for others to use correctly	Write a clear and concise engineering project plan
Finish reports or assignments on time	.521	.543	.726	.864	.585	.556	.591
Concentrate on technical engineering subjects	.591	.579	.664	.737	.521	.441	.606
Take class notes that will be useful in tech/engineering projects	.523	.331	.420	.461	.393	.350	.438
Use the library and search engines for engineering research	.541	.556	.562	.567	.456	.511	.516
Plan and organise your workload and technical study space	.677	.484	.609	.654	.496	.451	.534
Remember 'Engineering Design' lecture content	.476	.395	.564	.529	.521	.287	.391
Remember 'Engineering Design' practical session outputs	.577	.566	.498	.592	.511	.275	.491
Motivate yourself to study engineering	1.000	.643	.580	.544	.410	.403	.536
Take part in class-based engineering or tech discussions	.643	1.000	.618	.640	.499	.428	.559
Review instructions and estimate how long it will take to complete an engineering task	.580	.618	1.000	.740	.635	.639	.753
Design and construct an experiment that maintains precisely specified conditions	.544	.640	.740	1.000	.702	.661	.694
Lead a tech team to develop a new product to a successful result	.410	.499	.635	.702	1.000	.396	.618
Document technical procedures so that someone else could use them to produce the same result	.403	.428	.639	.661	.396	1.000	.815
Write a clear and concise engineering project plan	.536	.559	.753	.694	.618	.815	1.000

Table A10.43a Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 1 part 1

Inter-Item Correlation Matrix – Post

	Finish reports etc. on time	Concentrate on tech Eng subjects	Take useful class notes	Use library or search engines for Eng research	Plan and organise your work load and tech study space	Remember 'Engineering Design' lecture content	Remember 'Engineering Design' practical content
Finish reports or assignments on time	1.000	.823	.569	.532	.668	.539	.575
Concentrate on technical engineering subjects	.823	1.000	.603	.481	.690	.649	.785
Take class notes that will be useful in technical or engineering projects	.569	.603	1.000	.393	.739	.591	.467
Use the library and search engines for engineering research	.532	.481	.393	1.000	.501	.329	.382
Plan and organise your workload and technical study space	.668	.690	.739	.501	1.000	.762	.629
Remember 'Engineering Design' lecture content	.539	.649	.591	.329	.762	1.000	.764
Remember 'Engineering Design' practical session outputs	.575	.785	.467	.382	.629	.764	1.000
Motivate yourself to study engineering	.521	.591	.523	.541	.677	.476	.577
Take part in class based engineering or technical discussions	.543	.579	.331	.556	.484	.395	.566
Review instructions and estimate how long it will take to complete an engineering task	.726	.664	.420	.562	.609	.564	.498
Design and construct an experiment that maintains precisely specified conditions	.864	.737	.461	.567	.654	.529	.592
Lead a technical team to develop a new product to a successful result	.585	.521	.393	.456	.496	.521	.511
Document technical procedures so that someone else could use them to produce the same result	.556	.441	.350	.511	.451	.287	.275
Write a clear and concise engineering project plan	.591	.606	.438	.516	.534	.391	.491

Table A10.43b Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 1 part 2

Inter-Item Correlation Matrix – Post

	Motivate yourself to study Eng.	Take part in class based Eng or Technical discussions	Review and estimate how long to complete an Eng task.	Design and construct an experiment for specified conditions	Lead a tech team to develop a new product successfully	Document technical procedures for others to use correctly	Write a clear and concise engineering project plan
Finish reports or assignments on time	.521	.543	.726	.864	.585	.556	.591
Concentrate on technical engineering subjects	.591	.579	.664	.737	.521	.441	.606
Take class notes that will be useful in technical or engineering projects	.523	.331	.420	.461	.393	.350	.438
Use the library and search engines for engineering research	.541	.556	.562	.567	.456	.511	.516
Plan and organise your workload and technical study space	.677	.484	.609	.654	.496	.451	.534
Remember 'Engineering Design' lecture content	.476	.395	.564	.529	.521	.287	.391
Remember 'Engineering Design' practical session outputs	.577	.566	.498	.592	.511	.275	.491
Motivate yourself to study engineering	1.000	.643	.580	.544	.410	.403	.536
Take part in class based engineering or technical discussions	.643	1.000	.618	.640	.499	.428	.559
Review instructions and estimate how long it will take to complete an engineering task	.580	.618	1.000	.740	.635	.639	.753
Design and construct an experiment that maintains precisely specified conditions	.544	.640	.740	1.000	.702	.661	.694
Lead a technical team to develop a new product to a successful result	.410	.499	.635	.702	1.000	.396	.618
Document technical procedures so that someone else could use them to produce the same result	.403	.428	.639	.661	.396	1.000	.815
Write a clear and concise engineering project plan	.536	.559	.753	.694	.618	.815	1.000

Table A10.44a Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 2 part 1

Inter-Item Correlation Matrix – Pre

	Finish reports etc. on time	Concentrate on tech Eng subjects	Take useful class notes	Use library or search engines for Eng research	Plan and organise your work load and tech study space	Remember 'Engineering Design' lecture content	Remember 'Engineering Design' practical content
Finish reports or assignments on time	1.000	.366	.407	.214	.348	.054	.358
Concentrate on technical engineering subjects	.366	1.000	.256	.224	.191	.026	.197
Take class notes that will be useful in technical or engineering projects	.407	.256	1.000	.367	.335	.192	.484
Use the library and search engines for engineering research	.214	.224	.367	1.000	.098	.024	.293
Plan and organise your workload and technical study space	.348	.191	.335	.098	1.000	.094	.328
Remember 'Engineering Design' lecture content	.054	.026	.192	.024	.094	1.000	.107
Remember 'Engineering Design' practical session outputs	.358	.197	.484	.293	.328	.107	1.000
Motivate yourself to study engineering	.257	.345	.202	.149	.368	.009	.237
Take part in class based engineering or technical discussions	.276	.253	.318	.279	.294	-.063	.247
Review instructions and estimate how long it will take to complete an engineering task	.322	.318	.225	.079	.484	.095	.291
Design and construct an experiment that maintains precisely specified conditions	.110	.397	.359	.279	.189	.051	.232
Lead a technical team to develop a new product to a successful result	.182	.022	.044	.131	.344	.093	.289
Document technical procedures so that someone else could use them to produce the same result	.226	.126	.463	.213	.244	.187	.197
Write a clear and concise engineering project plan	.211	.138	.152	-.127	.405	-.039	.260

Table A10.44b Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 2 part 2

Inter-Item Correlation Matrix – Pre

	Motivate yourself to study Eng.	Take part in class based Eng or Technical discussions	Review and estimate how long to complete an Eng task.	Design and construct an experiment for specified conditions	Lead a tech team to develop a new product successfully	Document technical procedures for others to use correctly	Write a clear and concise engineering project plan
Finish reports or assignments on time	.257	.276	.322	.110	.182	.226	.211
Concentrate on technical engineering subjects	.345	.253	.318	.397	.022	.126	.138
Take class notes that will be useful in technical or engineering projects	.202	.318	.225	.359	.044	.463	.152
Use the library and search engines for engineering research	.149	.279	.079	.279	.131	.213	-.127
Plan and organise your workload and technical study space	.368	.294	.484	.189	.344	.244	.405
Remember 'Engineering Design' lecture content	.009	-.063	.095	.051	.093	.187	-.039
Remember 'Engineering Design' practical session outputs	.237	.247	.291	.232	.289	.197	.260
Motivate yourself to study engineering	1.000	.096	.338	.081	.067	.072	.165
Take part in class based engineering or technical discussions	.096	1.000	.224	.366	.376	.319	.247
Review instructions and estimate how long it will take to complete an engineering task	.338	.224	1.000	.128	.234	.182	.367
Design and construct an experiment that maintains precisely specified conditions	.081	.366	.128	1.000	.322	.319	.214
Lead a technical team to develop a new product to a successful result	.067	.376	.234	.322	1.000	.208	.453
Document technical procedures so that someone else could use them to produce the same result	.072	.319	.182	.319	.208	1.000	.464
Write a clear and concise engineering project plan	.165	.247	.367	.214	.453	.464	1.000

Table A10.45a Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 2 part 1

Inter-Item Correlation Matrix – Post	Finish reports etc. on time	Concentrate on tech Eng subjects	Take useful class notes	Use library or search engines for Eng research	Plan and organise your work load and tech study space	Remember 'Engineering Design' lecture content	Remember 'Engineering Design' practical content
Finish reports or assignments on time	1.000	.488	.521	.422	.461	.075	.281
Concentrate on technical engineering subjects	.488	1.000	.313	.386	.347	.246	.448
Take class notes that will be useful in technical or engineering projects	.521	.313	1.000	.392	.397	.182	.431
Use the library and search engines for engineering research	.422	.386	.392	1.000	.306	.397	.502
Plan and organise your workload and technical study space	.461	.347	.397	.306	1.000	.271	.292
Remember 'Engineering Design' lecture content	.075	.246	.182	.397	.271	1.000	.584
Remember 'Engineering Design' practical session outputs	.281	.448	.431	.502	.292	.584	1.000
Motivate yourself to study engineering	.265	.402	.320	.376	.585	.244	.289
Take part in class based engineering or technical discussions	.136	.136	.267	-.001	.336	.153	-.010
Review instructions and estimate how long it will take to complete an engineering task	.499	.359	.295	.318	.357	.196	.252
Design and construct an experiment that maintains precisely specified conditions	.233	.427	.077	-.005	.100	.292	.336
Lead a technical team to develop a new product to a successful result	.186	.318	.078	.155	.277	.258	.359
Document technical procedures so that someone else could use them to produce the same result	.471	.570	.275	.237	.246	-.001	.382
Write a clear and concise engineering project plan	.545	.487	.321	.286	.500	.185	.326

Table A10.45b Undergraduate responses for self-efficacy – Inter-Item Correlation statistics cohort 2 part 2

Inter-Item Correlation Matrix – Post

	Motivate yourself to study Eng.	Take part in class based Eng or Technical discussions	Review and estimate how long to complete an Eng task.	Design and construct an experiment for specified conditions	Lead a tech team to develop a new product successfully	Document technical procedures for others to use correctly	Write a clear and concise engineering project plan
Finish reports or assignments on time	.265	.136	.499	.233	.186	.471	.545
Concentrate on technical engineering subjects	.402	.136	.359	.427	.318	.570	.487
Take class notes that will be useful in technical or engineering projects	.320	.267	.295	.077	.078	.275	.321
Use the library and search engines for engineering research	.376	-.001	.318	-.005	.155	.237	.286
Plan and organise your workload and technical study space	.585	.336	.357	.100	.277	.246	.500
Remember 'Engineering Design' lecture content	.244	.153	.196	.292	.258	-.001	.185
Remember 'Engineering Design' practical session outputs	.289	-.010	.252	.336	.359	.382	.326
Motivate yourself to study engineering	1.000	.367	.425	.066	.376	.202	.264
Take part in class based engineering or technical discussions	.367	1.000	.352	.174	.306	-.089	.134
Review instructions and estimate how long it will take to complete an engineering task	.425	.352	1.000	.487	.564	.429	.485
Design and construct an experiment that maintains precisely specified conditions	.066	.174	.487	1.000	.567	.471	.402
Lead a technical team to develop a new product to a successful result	.376	.306	.564	.567	1.000	.333	.382
Document technical procedures so that someone else could use them to produce the same result	.202	-.089	.429	.471	.333	1.000	.759
Write a clear and concise engineering project plan	.264	.134	.485	.402	.382	.759	1.000

Table A10.46 Undergraduate self-efficacy – Summary item statistics

Summary Item Statistics							
Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.557	.275	.864	.589	3.144	.015	14
Cohort 1 Post	.372	-.048	.747	.795	-15.561	.029	14
Cohort 2 Pre	.226	-.127	.484	.612	-3.805	.017	14
Cohort 2 Post	.318	-.089	.759	.849	-8.486	.024	14

Table A10.47a Undergraduate responses for self-efficacy – Item-Total statistics cohort 1 Pre

Item-Total Statistics – Pre	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish reports or assignments on time	43.94	118.309	.816	.866	.940
Concentrate on tech eng' subjects	43.88	120.172	.826	.849	.940
Take class notes that will be useful in technical or engineering projects	44.06	125.184	.622	.647	.945
Use the library and search engines for engineering research	43.73	127.080	.627	.484	.945
Plan and organise your workload and technical study space	44.12	121.360	.794	.809	.940
Remember 'Engineering Design' lecture content	44.15	123.133	.677	.829	.944
Remember 'Engineering Design' practical session outputs	43.97	123.155	.710	.830	.943
Motivate yourself to study engineering	43.82	124.716	.698	.648	.943
Take part in class based engineering or technical discussions	44.15	124.008	.678	.611	.943
Review instructions & estimate how long it will take to complete an eng' task	44.24	119.814	.809	.798	.940
Design/construct an experiment that maintains precisely specified conditions	44.09	121.148	.852	.871	.939
Lead a technical team to develop a new product to a successful result	44.45	122.756	.672	.683	.944
Document technical procedures so that someone else could use them to produce the same result	44.52	124.508	.616	.804	.945
Write a clear & concise eng project plan	44.58	120.689	.758	.864	.941

Table A10.47b Undergraduate responses for self-efficacy – Item-Total statistics cohort 1 Post

Item-Total Statistics – Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish reports or assignments on time	47.39	75.245	.245	.524	.897
Concentrate on technical engineering subjects	46.90	73.690	.508	.749	.884
Take class notes that will be useful in technical or engineering projects	47.19	73.028	.543	.773	.883
Use the library and search engines for engineering research	47.32	68.026	.723	.745	.874
Plan and organise your workload and technical study space	47.23	72.914	.545	.772	.883
Remember 'Engineering Design' lecture content	47.71	64.946	.646	.645	.879
Remember 'Engineering Design' practical session outputs	47.42	70.785	.544	.661	.883
Motivate yourself to study engineering	47.19	71.828	.544	.560	.883
Take part in class based engineering or technical discussions	47.19	70.228	.599	.637	.880
Review instructions and estimate how long it will take to complete an engineering task	47.32	70.959	.611	.633	.880
Design and construct an experiment that maintains precisely specified conditions	47.29	69.146	.630	.700	.879
Lead a technical team to develop a new product to a successful result	47.45	69.256	.576	.708	.881
Document technical procedures so that someone else could use them to produce the same result	47.19	71.561	.620	.782	.880
Write a clear and concise engineering project plan	47.35	67.703	.715	.811	.875

Table A10.47c Undergraduate responses for self-efficacy – Item-Total statistics cohort 2 Pre

Item-Total Statistics –Pre

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish reports or assignments on time	49.94	67.649	.369	.343	.488
Concentrate on technical engineering subjects	49.82	69.788	.303	.394	.501
Take class notes that will be useful in technical or engineering projects	50.02	65.393	.497	.534	.469
Use the library and search engines for engineering research	49.82	69.766	.237	.317	.505
Plan and organise your workload and technical study space	50.16	66.762	.437	.415	.480
Remember 'Engineering Design' lecture content	49.38	37.698	.114	.147	.814
Remember 'Engineering Design' practical session outputs	49.82	68.260	.427	.370	.489
Motivate yourself to study engineering	49.59	70.088	.242	.256	.506
Take part in class based engineering or technical discussions	49.98	68.202	.296	.332	.495
Review instructions and estimate how long it will take to complete an engineering task	50.10	68.136	.389	.349	.489
Design and construct an experiment that maintains precisely specified conditions	50.04	68.627	.342	.398	.494
Lead a technical team to develop a new product to a successful result	50.21	67.764	.337	.450	.490
Document technical procedures so that someone else could use them to produce the same result	50.09	66.891	.443	.459	.480
Write a clear and concise engineering project plan	50.13	69.016	.278	.529	.499

Table A10.47d Undergraduate responses for self-efficacy – Item-Total statistics cohort 2 Post

Item-Total Statistics – Post

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish reports or assignments on time	48.33	44.227	.574	.585	.852
Concentrate on technical engineering subjects	48.27	46.117	.627	.542	.851
Take class notes that will be useful in technical or engineering projects	48.31	46.602	.492	.475	.857
Use the library and search engines for engineering research	48.25	46.489	.485	.505	.857
Plan and organise your workload and technical study space	48.50	45.064	.573	.567	.852
Remember 'Engineering Design' lecture content	48.85	46.425	.385	.558	.865
Remember 'Engineering Design' practical session outputs	48.48	45.063	.575	.637	.852
Motivate yourself to study engineering	48.17	46.567	.533	.559	.855
Take part in class based engineering or technical discussions	48.35	49.127	.280	.417	.867
Review instructions and estimate how long it will take to complete an engineering task	48.48	45.276	.641	.592	.849
Design and construct an experiment that maintains precisely specified conditions	48.38	47.814	.457	.611	.859
Lead a technical team to develop a new product to a successful result	48.52	45.148	.514	.546	.856
Document technical procedures so that someone else could use them to produce the same result	48.50	46.766	.536	.774	.855
Write a clear and concise engineering project plan	48.50	44.468	.646	.739	.848

Supporting tables for postgraduate cohorts

Table A10.48a Postgraduate distribution tests for normality in the importance of knowledge category by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Accounting & Finance	.806	34	.000	.771	30	.000
Sales and Marketing	.850	34	.000	.786	30	.000
Human Resource Management	.765	34	.000	.804	30	.000
Project planning	.678	34	.000	.774	30	.000
Design and Production	.834	34	.000	.790	30	.000
Quality Management	.763	34	.000	.754	30	.000
Legal aspects	.809	34	.000	.761	30	.000

Table A10.48b Postgraduate distribution tests for normality in the importance of knowledge category by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Accounting & Finance	.760	46	.000	.675	47	.000
Sales and Marketing	.781	46	.000	.818	47	.000
Human Resource Management	.801	46	.000	.786	47	.000
Project planning	.581	46	.000	.504	47	.000
Design and Production	.764	46	.000	.744	47	.000
Quality Management	.700	46	.000	.703	47	.000
Legal aspects	.736	46	.000	.750	47	.000

Table A10.49a Postgraduate distribution tests for normality in the importance of skills category by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Give effective presentations	.803	34	.000	.766	30	.000
Produce quality reports	.827	34	.000	.800	30	.000
Be creative	.845	34	.000	.848	30	.001
Solve problems	.627	34	.000	.749	30	.000
Formulate good questions	.866	34	.001	.807	30	.000
Work effectively in a team	.750	34	.000	.765	30	.000
Design and produce products/services	.873	34	.001	.785	30	.000
Communicate effectively	.717	34	.000	.732	30	.000
Use discussion to investigate an issue	.846	34	.000	.765	30	.000

Table A10.49b Postgraduate distribution tests for normality in the importance of skills category by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Give effective presentations	.722	46	.000	.748	47	.000
Produce quality reports	.696	46	.000	.750	47	.000
Be creative	.707	46	.000	.768	47	.000
Solve problems	.589	46	.000	.575	47	.000
Formulate good questions	.788	46	.000	.775	47	.000
Work effectively in a team	.629	46	.000	.642	47	.000
Design and produce products/services	.814	46	.000	.809	47	.000
Communicate effectively	.616	46	.000	.609	47	.000
Use discussion to investigate an issue	.814	46	.000	.752	47	.000

Table A10.50 Postgraduate distribution tests for normality in the importance of improvement category by data collection Cohorts 1 and 2.

Tests of Normality - Cohorts 1 & 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
IMPROV_Cohort 1	.498	34	.000	.612	30	.000
IMPROV_Cohort 2	.696	46	.000	.581	47	.000

Table A10.51a Postgraduate distribution tests for normality in self-esteem by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem solving	.792	34	.000	.664	30	.000
Getting resources	.758	34	.000	.807	30	.000
Achieving aims/goals	.791	34	.000	.775	30	.000
Deal with unexpected events	.827	34	.000	.808	30	.000
Resourcefulness	.808	34	.000	.750	30	.000
Relying on oneself	.853	34	.000	.853	30	.001
Investing the approriate effort	.727	34	.000	.774	30	.000
Sticking to my plans	.767	34	.000	.838	30	.000
Being calm under stress	.849	34	.000	.789	30	.000
Generating solutions to problems	.828	34	.000	.832	30	.000
Coping with uncertainty	.823	34	.000	.766	30	.000
Acceptance of challenges	.760	34	.000	.811	30	.000
Thinking around a problem	.865	34	.001	.814	30	.000
Making sensible judgments	.858	34	.000	.810	30	.000
Sticking to my plans 2	.875	34	.001	.845	30	.000

Table A10.51b Postgraduate distribution tests for normality in self-esteem by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem solving	.781	46	.000	.852	47	.000
Getting resources	.719	46	.000	.739	47	.000
Achieving aims/goals	.804	46	.000	.864	47	.000
Deal with unexpected events	.804	46	.000	.861	47	.000
Resourcefulness	.818	46	.000	.820	47	.000
Relying on oneself	.885	46	.000	.864	47	.000
Investing the approriate effort	.740	46	.000	.640	47	.000
Sticking to my plans	.848	46	.000	.794	47	.000
Being calm under stress	.773	46	.000	.810	47	.000
Generating solutions to problems	.798	46	.000	.833	47	.000
Coping with uncertainty	.740	46	.000	.849	47	.000
Acceptance of challenges	.838	46	.000	.893	47	.000
Thinking around a problem	.619	46	.000	.571	47	.000
Making sensible judgments	.833	46	.000	.771	47	.000
Sticking to my plans 2	.904	46	.001	.858	47	.000

Table A10.52a Postgraduate distribution tests for normality in self-efficacy by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Finish reports or assignments on time	.783	34	.000	.800	30	.000
Concentrate on technical engineering subjects	.800	34	.000	.750	30	.000
Take class notes that will be useful in technical or engineering projects	.849	34	.000	.853	30	.001
Use the library and search engines for engineering research	.844	34	.000	.834	30	.000
Plan and organise your workload and technical study space	.861	34	.000	.740	30	.000
Remember 'Engineering Design' lecture content	.881	34	.002	.790	30	.000
Remember 'Engineering Design' practical session outputs	.870	34	.001	.729	30	.000
Motivate yourself to study engineering	.791	34	.000	.788	30	.000
Take part in class based engineering or technical discussions	.799	34	.000	.798	30	.000
Review instructions and estimate how long it will take to complete an engineering task	.784	34	.000	.798	30	.000
Design and construct an experiment that maintains precisely specified conditions	.876	34	.001	.851	30	.001
Lead a technical team to develop a new product to a successful result	.900	34	.005	.811	30	.000
Document technical procedures so that someone else could use them to produce the same result	.828	34	.000	.775	30	.000
Write a clear and concise engineering project plan	.800	34	.000	.834	30	.000

Table A10.52b Postgraduate distribution tests for normality in self-efficacy by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
Finish reports or assignments on time	.740	46	.000	.743	47	.000
Concentrate on technical engineering subjects	.783	46	.000	.827	47	.000
Take class notes that will be useful in technical or engineering projects	.713	46	.000	.848	47	.000
Use the library and search engines for engineering research	.759	46	.000	.775	47	.000
Plan and organise your workload and technical study space	.773	46	.000	.803	47	.000
Remember 'Engineering Design' lecture content	.828	46	.000	.869	47	.000
Remember 'Engineering Design' practical session outputs	.856	46	.000	.859	47	.000
Motivate yourself to study engineering	.723	46	.000	.790	47	.000
Take part in class based engineering or technical discussions	.763	46	.000	.808	47	.000
Review instructions and estimate how long it will take to complete an engineering task	.828	46	.000	.815	47	.000
Design and construct an experiment that maintains precisely specified conditions	.848	46	.000	.875	47	.000
Lead a technical team to develop a new product to a successful result	.881	46	.000	.840	47	.000
Document technical procedures so that someone else could use them to produce the same result	.809	46	.000	.842	47	.000
Write a clear and concise engineering project plan	.862	46	.000	.795	47	.000

Table A10.53a Postgraduate distribution tests for normality in learning style preference by data collection Cohort 1.

Tests of Normality - Cohort 1						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	.703	34	.000	.542	30	.000
If I am going somewhere new and need directions I usually	.514	34	.000	.628	30	.000
If I am cooking a new dish I generally	.688	34	.000	.778	30	.000
If I am teaching someone something new I tend to	.791	34	.000	.808	30	.000
In general conversation I would tend to say	.805	34	.000	.751	30	.000
During my free time I would rather	.802	34	.000	.772	30	.000
If I were choosing a holiday I would prefer to	.805	34	.000	.743	30	.000
If I were out shopping for clothes I would tend to	.541	34	.000	.653	30	.000
When I concentrate, I most often	.809	34	.000	.794	30	.000
When I am learning a new skill I feel most comfortable when	.737	34	.000	.754	30	.000

Table A10.53b Postgraduate distribution tests for normality in the learning style preference by data collection Cohort 2.

Tests of Normality - Cohort 2						
	Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	.602	46	.000	.641	47	.000
If I am going somewhere new and need directions I usually	.446	46	.000	.363	47	.000
If I am cooking a new dish I generally	.750	46	.000	.713	47	.000
If I am teaching someone something new I tend to	.799	46	.000	.791	47	.000
In general conversation I would tend to say	.777	46	.000	.802	47	.000
During my free time I would rather	.783	46	.000	.775	47	.000
If I were choosing a holiday I would prefer to	.800	46	.000	.806	47	.000
If I were out shopping for clothes I would tend to	.433	46	.000	.461	47	.000
When I concentrate, I most often	.727	46	.000	.773	47	.000
When I am learning a new skill I feel most comfortable when	.602	46	.000	.705	47	.000

Table A10.54a PG responses of the importance of existing knowledge split by data collection Cohort 1.

Knowledge Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Accounting & Finance	Pre	3.94	1.127	-1.230	1.136
Accounting & Finance	Post	4.34	.653	-.486	-.603
Sales and Marketing	Pre	3.82	1.141	-.934	.432
Sales and Marketing	Post	4.22	.751	-.390	-1.081
Human Resource Management	Pre	3.88	1.149	-1.415	1.659
Human Resource Management	Post	3.91	.689	.123	-.768
Project planning	Pre	4.18	1.218	-1.749	2.294
Project planning	Post	4.31	.644	-.392	-.599
Design and Production	Pre	3.88	1.149	-.905	.391
Design and Production	Post	4.19	.693	-.267	-.804
Quality Management	Pre	4.12	1.066	-1.521	2.492
Quality Management	Post	4.34	.602	-.295	-.572
Legal aspects	Pre	3.88	1.094	-1.228	1.297
Legal aspects	Post	4.31	.780	-.628	-1.046

Table A10.54b PG responses of the importance of existing knowledge by data collection Cohort 2.

Knowledge Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Accounting & Finance	Pre	4.21	.793	-1.355	3.718
Accounting & Finance	Post	4.32	.513	.315	-.854
Sales and Marketing	Pre	4.08	.781	-1.142	3.274
Sales and Marketing	Post	4.12	.746	-.507	-.038
Human Resource Management	Pre	4.17	.849	-1.122	2.131
Human Resource Management	Post	4.20	.782	-.905	.810
Project planning	Pre	4.57	.694	-2.760	12.188
Project planning	Post	4.78	.418	-1.394	-.061
Design and Production	Pre	4.08	.756	-1.238	4.035
Design and Production	Post	4.40	.639	-.587	-.556
Quality Management	Pre	4.42	.770	-1.933	6.126
Quality Management	Post	4.48	.677	-1.361	2.340
Legal aspects	Pre	4.36	.787	-1.726	5.021
Legal aspects	Post	4.42	.642	-.654	-.507

Table A10.55a PG responses of the importance of skills split by data collection Cohort 1.

Skill Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Give effective presentations	Pre Post	3.97 4.09	1.087 .588	-1.294 -.007	1.626 .108
Produce quality reports	Pre Post	3.82 4.22	1.141 .751	-1.065 -.878	.599 1.046
Be creative	Pre Post	3.88 4.00	.977 .880	-.993 -.303	1.159 -.962
Solve problems	Pre Post	4.26 4.41	1.214 .615	-1.949 -.507	2.954 -.548
Formulate good questions	Pre Post	3.74 4.06	.994 .716	-.802 -.092	.547 -.944
Work effectively in a team	Pre Post	4.03 4.19	1.218 .592	-1.448 -.054	1.433 -.160
Design & produce products/services	Pre Post	3.74 4.06	.963 .619	-.723 -.034	.707 -.171
Communicate effectively	Pre Post	4.12 4.47	1.175 .621	-1.671 -.735	2.394 -.349
Use discussion to investigate issues	Pre Post	3.91 4.16	.996 .628	-.988 -.118	1.020 -.359

Table A10.55b PG responses of the importance of skills split by data collection Cohort 2.

Skill Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Give effective presentations	Pre Post	4.26 4.32	.738 .561	-1.663 -.048	6.086 .590
Produce quality reports	Pre Post	4.30 4.38	.749 .622	-1.707 -.550	5.937 -.551
Be creative	Pre Post	4.34 4.57	.765 .645	-1.843 -.457	5.962 -.625
Solve problems	Pre Post	4.57 4.66	.721 .479	-2.641 -.695	10.464 -1.591
Formulate good questions	Pre Post	4.19 4.25	.833 .686	-1.202 -.368	2.568 -.797
Work effectively in a team	Pre Post	4.53 4.61	.775 .618	-2.290 -1.384	7.258 .911
Design & produce products/services	Pre Post	4.06 4.16	.886 .745	-.803 -.622	.969 .252
Communicate effectively	Pre Post	4.57 4.59	.721 .497	-2.641 -.383	10.464 -1.944
Use discussion to investigate issues	Pre Post	4.13 4.20	.878 .594	-.975 -.079	1.406 -.279

Table A10.56 PG responses of the importance of improvement split by data collection both Cohorts.

Improve Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Opportunity to Improve	Cohort 1 Pre Cohort 1 Post	4.79 4.63	.410 .492	-1.523 -.542	.788 .809
	Cohort 2 Pre Cohort 2 Post	4.49 4.74	.718 .539	-1.431 -2.066	1.993 3.561

Table A10.57a PG responses of their confidence in their current abilities (Self-Esteem) split by data collection Cohort 1.

Self-Esteem Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Problem solving	Pre	3.76	.699	.360	-.834
	Post	4.03	.538	.035	.862
Getting resources	Pre	3.62	.652	.580	-.557
	Post	3.91	.689	.123	-.768
Achieving aims/goals	Pre	3.50	.749	-.690	-.156
	Post	3.88	.660	-.584	1.288
Deal with unexpected events	Pre	3.41	.743	-.384	-.372
	Post	3.97	.782	.056	-1.328
Resourcefulness	Pre	3.53	.662	.219	-.114
	Post	4.00	.622	.000	-.178
Relying on oneself	Pre	3.03	.870	.528	-.271
	Post	3.53	.761	-.346	-.115
Investing the appropriate effort	Pre	3.82	.673	-1.047	2.059
	Post	4.34	.653	-.486	-.603
Sticking to my plans	Pre	2.85	.857	.297	-1.595
	Post	3.53	.879	-1.012	1.163
Being calm under stress	Pre	3.44	1.050	-.169	-1.202
	Post	3.97	.861	-.909	.734
Generating solutions to problems	Pre	3.68	.727	-.412	.260
	Post	3.94	.716	-.471	.624
Coping with uncertainty	Pre	3.68	.684	-.087	-.003
	Post	4.13	.609	-.057	-.155
Acceptance of challenges	Pre	3.35	.734	-.677	-.795
	Post	3.72	.683	-.224	.208
Thinking around a problem	Pre	3.62	.817	-.226	-.268
	Post	3.97	.695	-.574	1.088
Making sensible judgments	Pre	3.65	.774	-.110	-.205
	Post	4.00	.718	.000	-.962
Sticking to my plans 2	Pre	3.62	.888	-.241	-.522
	Post	4.00	.803	-.398	-.304

Table A10.57b PG responses of their confidence in their current abilities (Self-Esteem) split by data collection Cohort 2.

Self-Esteem Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Problem solving	Pre	3.79	.689	-1.167	4.139
	Post	3.91	.830	-.336	-.426
Getting resources	Pre	3.60	.689	-.756	2.649
	Post	3.52	.664	-.585	-.018
Achieving aims/goals	Pre	3.66	.783	-.809	1.688
	Post	3.73	.788	-.062	-.420
Deal with unexpected events	Pre	3.66	.783	-.809	1.688
	Post	3.57	.818	-.096	-.387
Resourcefulness	Pre	3.55	.722	-.648	1.913
	Post	3.68	.708	-.276	.118
Relying on oneself	Pre	2.83	.955	.079	-.822
	Post	2.82	.971	.702	-.181
Investing the appropriate effort	Pre	4.02	.747	-1.472	4.827
	Post	4.16	.861	-2.152	6.894
Sticking to my plans	Pre	2.72	.863	.407	-.272
	Post	2.34	.745	.755	.441
Being calm under stress	Pre	3.87	.761	-1.134	3.184
	Post	3.70	.668	-.564	.617
Generating solutions to problems	Pre	3.60	.743	-.957	2.041
	Post	3.73	.788	-.658	.335
Coping with uncertainty	Pre	3.68	.701	-.851	2.886
	Post	3.55	.901	-.342	-.617
Acceptance of challenges	Pre	3.32	.894	-.692	.217
	Post	3.32	1.052	-.184	-.906
Thinking around a problem	Pre	3.85	.662	-1.894	6.734
	Post	3.84	.608	-2.521	10.398
Making sensible judgments	Pre	3.72	.818	-.742	1.408
	Post	3.73	.660	-1.169	1.623
Sticking to my plans 2	Pre	3.42	.989	-.189	-.542
	Post	3.20	.823	-.404	-.012

Table A10.58a PG responses of their confidence in their future abilities (Self-Efficacy) split by data collection Cohort 1.

Self-Efficacy Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Finish reports or assignments on time	Pre	4.26	.751	-.487	-1.032
	Post	4.16	.723	-.248	-.981
Concentrate on technical engineering subjects	Pre	3.88	.686	.153	-.761
	Post	4.03	.595	-.005	.107
Take class notes that will be useful in technical or engineering projects	Pre	3.44	.824	-.320	-.500
	Post	3.91	.777	-.272	-.240
Use the library and search engines for engineering research	Pre	3.85	.744	-.222	-.096
	Post	4.06	.801	-.518	-.126
Plan and organise your workload and technical study space	Pre	3.91	.866	-.418	-.390
	Post	4.16	.574	.016	.084
Remember 'Engineering Design' lecture content	Pre	3.44	.894	.052	-.629
	Post	3.88	.793	.233	-1.349
Remember 'Engineering Design' practical session outputs	Pre	3.41	.988	.060	-.045
	Post	3.94	.564	-.027	.442
Motivate yourself to study engineering	Pre	4.00	.651	.000	-.466
	Post	4.06	.716	-.656	1.072
Take part in class based engineering or technical discussions	Pre	4.18	.758	-.312	-1.152
	Post	4.09	.689	-.123	-.768
Review instructions and estimate how long it will take to complete an engineering task	Pre	3.88	.640	.102	-.425
	Post	4.03	.647	-.028	-.416
Design and construct an experiment that maintains precisely specified conditions	Pre	3.53	.896	-.497	.791
	Post	3.94	.759	-.365	.033
Lead a technical team to develop a new product to a successful result	Pre	3.35	.950	-.339	-.079
	Post	3.97	.740	.050	-1.096
Document technical procedures so that someone else could use them to produce the same result	Pre	3.47	.788	.498	-.185
	Post	4.22	.659	-.261	-.625
Write a clear and concise engineering project plan	Pre	3.88	.686	.153	-.761
	Post	4.09	.777	-.608	.243

Table A10.58b PG responses of their confidence in their future abilities (Self-Efficacy) split by data collection Cohort 2.

Self-Efficacy Category	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
Finish reports or assignments on time	Pre	4.45	.637	-.743	-.409
	Post	4.41	.622	-.550	-.551
Concentrate on technical engineering subjects	Pre	4.15	.864	-1.233	2.352
	Post	4.14	.668	-.160	-.680
Take class notes that will be useful in technical or engineering projects	Pre	4.38	.686	-1.024	1.405
	Post	3.89	.784	-.401	-.012
Use the library and search engines for engineering research	Pre	4.17	.802	-1.483	4.069
	Post	4.27	.727	-.855	.830
Plan and organise your workload and technical study space	Pre	4.15	.690	-.207	-.841
	Post	4.11	.722	-.175	-1.012
Remember 'Engineering Design' lecture content	Pre	3.75	.806	.254	-.979
	Post	3.79	.833	-.360	-.238
Remember 'Engineering Design' practical session outputs	Pre	3.77	.776	-.091	-.420
	Post	3.63	.874	-.300	-.461
Motivate yourself to study engineering	Pre	4.34	.586	-.228	-.620
	Post	4.16	.776	-.914	1.073
Take part in class based engineering or technical discussions	Pre	4.11	.824	-1.288	3.069
	Post	4.05	.861	-1.233	2.678
Review instructions and estimate how long it will take to complete an engineering task	Pre	4.04	.784	-.566	.128
	Post	3.95	.834	-1.172	2.779
Design and construct an experiment that maintains precisely specified conditions	Pre	3.91	.766	-.103	-.645
	Post	3.64	.810	-.052	-.407
Lead a technical team to develop a new product to a successful result	Pre	3.66	.979	-.279	-.297
	Post	3.74	.902	-.682	.873
Document technical procedures so that someone else could use them to produce the same result	Pre	3.92	.730	.118	-1.071
	Post	3.61	.813	-.250	-.283
Write a clear and concise engineering project plan	Pre	3.87	.833	-.159	-.724
	Post	4.14	.702	-.618	.791

Table A10.59a PG responses of their learning style preference (VAK) split by data collection Cohort 1.

Learning Preference Item	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
When I operate new equipment I generally	Pre	1.62	.817	.836	-.959
	Post	1.39	.761	1.624	.892
If I am going somewhere new and need directions I usually	Pre	1.32	.684	1.897	2.106
	Post	1.44	.669	1.277	.488
If I am cooking a new dish I generally	Pre	1.76	.923	.503	-1.685
	Post	1.78	.832	.443	-1.415
If I am teaching someone something new I tend to	Pre	2.24	.741	-.414	-1.026
	Post	2.09	.777	-.168	-1.287
In general conversation, I would tend to say	Pre	1.97	.797	.054	-1.404
	Post	1.69	.592	.194	-.518
During my free time, I would rather	Pre	2.15	.702	-.213	-.867
	Post	2.31	.693	-.510	-.741
If I were choosing a holiday I would prefer to	Pre	1.97	.797	.054	-1.404
	Post	2.09	.893	-.192	-1.763
If I were out shopping for clothes I would tend to	Pre	2.59	.783	-1.517	.493
	Post	2.55	.723	-1.311	.315
When I concentrate, I most often	Pre	1.91	.753	.149	-1.171
	Post	1.94	.669	.070	-.611
When I am learning a new skill, I feel most comfortable when	Pre	2.21	.880	-.429	-1.601
	Post	2.09	.893	-.192	-1.763

Table A10.59b PG responses of their learning style preference (VAK) split by data collection Cohort 2.

Learning Preference Item	Data Set	Mean Statistic	Std. Dev Statistic	Skewness Statistic	Kurtosis Statistic
When I operate new equipment I generally	Pre	1.42	.719	1.439	.557
	Post	1.46	.706	1.235	.166
If I am going somewhere new and need directions I usually	Pre	1.17	.427	2.549	6.305
	Post	1.12	.385	3.450	12.378
If I am cooking a new dish I generally	Pre	1.77	.847	.459	-1.459
	Post	1.82	.919	.374	-1.746
If I am teaching someone something new I tend to	Pre	2.19	.681	-.253	-.792
	Post	2.22	.737	-.376	-1.046
In general conversation, I would tend to say	Pre	1.92	.589	.011	.005
	Post	1.82	.748	.309	-1.124
During my free time, I would rather	Pre	2.26	.763	-.494	-1.105
	Post	2.22	.648	-.243	-.623
If I were choosing a holiday I would prefer to	Pre	2.04	.808	-.070	-1.458
	Post	2.04	.781	-.071	-1.339
If I were out shopping for clothes I would tend to	Pre	2.75	.648	-2.367	3.857
	Post	2.68	.713	-1.908	1.873
When I concentrate, I most often	Pre	1.85	.533	-.147	.359
	Post	1.96	.638	.032	-.419
When I am learning a new skill, I feel most comfortable when	Pre	2.62	.686	-1.578	1.073
	Post	2.34	.848	-.729	-1.214

Table A10.60a Normality tests PG Cohort 1 of the importance of existing knowledge by gender.

Knowledge Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Accounting and Finance	Pre	.000	.048
	Post	.000	.015
Sales and Marketing	Pre	.000	.025
	Post	.000	.012
Human Resource Management	Pre	.000	.004
	Post	.001	.012
Project planning	Pre	.000	.000
	Post	.000	.015
Design and Production	Pre	.004	.002
	Post	.000	.036
Quality Management	Pre	.000	.001
	Post	.000	.015
Legal aspects	Pre	.000	.079
	Post	.000	.025

Table A10.60b Normality tests PG Cohort 2 of the importance of existing knowledge by gender.

Knowledge Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Accounting and Finance	Pre	.000	.000
	Post	.000	.000
Sales and Marketing	Pre	.000	.001
	Post	.000	.007
Human Resource Management	Pre	.000	.001
	Post	.000	.003
Project planning	Pre	.000	.000
	Post	.000	.000
Design and Production	Pre	.000	.000
	Post	.000	.000
Quality Management	Pre	.000	.000
	Post	.000	.000
Legal aspects	Pre	.000	.000
	Post	.000	.000

Table A10.61a Normality tests PG Cohort 1 responses of the importance of skills and of the opportunity to improve by gender.

Skill Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Give effective presentations	Pre Post	.001 .000	.009 .000
Produce quality Reports	Pre Post	.001 .001	.032 .000
Be creative	Pre Post	.007 .001	.009 .001
Solve problems	Pre Post	.000 .000	.000 .015
Formulate good Questions	Pre Post	.033 .000	.014 .017
Work effectively in a team	Pre Post	.000 .000	.001 .004
Design & produce products/services	Pre Post	.032 .000	.005 .015
Communicate Effectively	Pre Post	.000 .000	.000 .004
Use discussion to investigate issues	Pre Post	.006 .000	.020 .000
Opportunity to Improve	Pre	.000	.000
	Post	.000	.000

Table A10.61b Normality tests PG Cohort 2 responses of the importance of skills and of the opportunity to improve by gender.

Skill Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Give effective presentations	Pre Post	.000 .000	.000 .000
Produce quality Reports	Pre Post	.000 .000	.000 .000
Be creative	Pre Post	.000 .000	.000 .000
Solve problems	Pre Post	.000 .000	.000 .000
Formulate good Questions	Pre Post	.000 .000	.000 .000
Work effectively in a team	Pre Post	.000 .000	.000 .000
Design & produce products/services	Pre Post	.000 .000	.000 .000
Communicate Effectively	Pre Post	.000 .000	.000 .000
Use discussion to investigate issues	Pre Post	.000 .000	.000 .000
Opportunity to Improve	Pre	.000	.000
	Post	.000	.000

Table A10.62a Normality tests PG Cohort 1 responses of their self-esteem by gender.

Self-Esteem Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Problem solving	Pre Post	.000 .000	.008 .004
Getting resources	Pre Post	.000 .001	.002 .015
Achieving aims/goals	Pre Post	.000 .000	.001 .000
Deal with unexpected events	Pre Post	.010 .001	.000 .008
Resourcefulness	Pre Post	.000 .001	.003 .000
Relying on oneself	Pre Post	.001 .004	.078 .000
Investing the appropriate effort	Pre Post	.000 .000	.002 .008
Sticking to my plans	Pre Post	.000 .007	.000 .000
Being calm under stress	Pre Post	.002 .000	.062 .036
Generating solutions to problems	Pre Post	.015 .000	.001 .000
Coping with uncertainty	Pre Post	.000 .000	.009 .035
Acceptance of challenges	Pre Post	.000 .001	.000 .015
Thinking around a problem	Pre Post	.004 .000	.008 .000
Making sensible judgments	Pre Post	.017 .001	.005 .025
Sticking to my plans 2	Pre Post	.010 .005	.009 .004

Table A10.62b Normality tests PG Cohort 2 responses of their self-esteem by gender.

Self-Esteem Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Problem solving	Pre Post	.000 .000	.000 .000
Getting resources	Pre Post	.000 .000	.000 .000
Achieving aims/goals	Pre Post	.000 .000	.001 .012
Deal with unexpected events	Pre Post	.000 .001	.000 .000
Resourcefulness	Pre Post	.000 .001	.000 .000
Relying on oneself	Pre Post	.015 .005	.000 .005
Investing the appropriate effort	Pre Post	.000 .000	.000 .000
Sticking to my plans	Pre Post	.001 .000	.005 .001
Being calm under stress	Pre Post	.000 .000	.001 .002
Generating solutions to problems	Pre Post	.000 .000	.006 .002
Coping with uncertainty	Pre Post	.001 .000	.000 .004
Acceptance of challenges	Pre Post	.005 .006	.003 .018
Thinking around a problem	Pre Post	.000 .000	.000 .000
Making sensible judgments	Pre Post	.000 .000	.000 .000
Sticking to my plans 2	Pre Post	.000 .001	.011 .001

Table A10.63a Normality tests PG Cohort 1 responses of their self-efficacy by gender.

Self-Efficacy Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
Finish reports or assignments on time	Pre Post	.001 .000	.001 .006
Concentrate on technical engineering subjects	Pre Post	.000 .001	.005 .000
Take class notes that will be useful in technical or engineering projects	Pre Post	.000 .001	.040 .149
Use the library and search engines for engineering research	Pre Post	.012 .003	.003 .036
Plan and organise your workload and technical study space	Pre Post	.023 .000	.006 .025
Remember 'Engineering Design' lecture content	Pre Post	.001 .001	.007 .006
Remember 'Engineering Design' practical session outputs	Pre Post	.002 .000	.019 .000
Motivate yourself to study engineering	Pre Post	.000 .000	.009 .045
Take part in class based engineering or technical discussions	Pre Post	.001 .000	.001 .025
Review instructions and estimate how long it will take to complete an engineering task	Pre Post	.000 .001	.003 .000
Design and construct an experiment that maintains precisely specified conditions	Pre Post	.017 .001	.008 .025
Lead a technical team to develop a new product to a successful result	Pre Post	.046 .001	.088 .036
Document technical procedures so that someone else could use them to produce the same result	Pre Post	.002 .000	.005 .015
Write a clear and concise engineering project plan	Pre Post	.000 .001	.005 .036

Table A10.63b Normality tests PG Cohort 2 responses of their self-efficacy by gender.

Self-Efficacy Category	Data Set	Shapiro-Wilk Sig.	
		M	F
Finish reports or assignments on time	Pre Post	.000 .000	.000 .001
Concentrate on technical engineering subjects	Pre Post	.000 .000	.000 .000
Take class notes that will be useful in technical or engineering projects	Pre Post	.000 .001	.000 .009
Use the library and search engines for engineering research	Pre Post	.000 .000	.000 .000
Plan and organise your workload and technical study space	Pre Post	.000 .000	.001 .001
Remember 'Engineering Design' lecture content	Pre Post	.000 .001	.003 .001
Remember 'Engineering Design' practical session outputs	Pre Post	.000 .001	.004 .006
Motivate yourself to study engineering	Pre Post	.000 .000	.000 .001
Take part in class based engineering or technical discussions	Pre Post	.000 .000	.000 .001
Review instructions and estimate how long it will take to complete an engineering task	Pre Post	.000 .000	.008 .009
Design and construct an experiment that maintains precisely specified conditions	Pre Post	.000 .003	.003 .002
Lead a technical team to develop a new product to a successful result	Pre Post	.001 .001	.005 .000
Document technical procedures so that someone else could use them to produce the same result	Pre Post	.000 .000	.000 .006
Write a clear and concise engineering project plan	Pre Post	.001 .000	.005 .000

Table A10.64a Normality tests PG Cohort 1 responses of their learning style preference by gender.

Learning Style Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
When I operate new equipment I generally	Pre Post	.000 .000	.000 .000
If I am going somewhere new and need directions I usually	Pre Post	.000 .000	.000 .015
If I am cooking a new dish I generally	Pre Post	.000 .000	.000 .001
If I am teaching someone something new I tend to	Pre Post	.000 .000	.007 .022
In general conversation I would tend to say	Pre Post	.001 .000	.006 .000
During my free time I would rather	Pre Post	.000 .000	.009 .000
If I were choosing a holiday I would prefer to	Pre Post	.001 .000	.010 .002
If I were out shopping for clothes I would tend to	Pre Post	.000 .000	.000 .000
When I concentrate, I most often	Pre Post	.001 .000	.002 .025
When I am learning a new skill I feel most comfortable when	Pre Post	.000 .000	.001 .017

Table A10.64b Normality tests PG Cohort 2 responses of their learning style preference by gender.

Learning Style Category	**Data Set**	**Shapiro-Wilk Sig.**	
		M	**F**
When I operate new equipment I generally	Pre Post	.000 .000	.000 .000
If I am going somewhere new and need directions I usually	Pre Post	.000 .000	.000 .000
If I am cooking a new dish I generally	Pre Post	.000 .000	.000 .000
If I am teaching someone something new I tend to	Pre Post	.000 .000	.000 .000
In general conversation I would tend to say	Pre Post	.000 .000	.000 .001
During my free time I would rather	Pre Post	.000 .000	.001 .000
If I were choosing a holiday I would prefer to	Pre Post	.000 .000	.000 .001
If I were out shopping for clothes I would tend to	Pre Post	.000 .000	.000 .000
When I concentrate, I most often	Pre Post	.000 .000	.000 .001
When I am learning a new skill I feel most comfortable when	Pre Post	.000 .000	.000 .000

Table A10.65a Hypothesis tests PG Cohort 1 of gender differences in the importance of existing knowledge.

Knowledge Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Accounting and Finance	.616	.743	Slightly less significant
Sales and Marketing	.396	.781	Moderately less significant
Human Resource Management	.986	.631	Moderately more significant
Project planning	.396	.705	Moderately less significant
Design and Production	.641	.781	Slightly less significant
Quality Management	.877	.900	Virtually unchanged
Legal aspects	.341	.860	Highly less significant

Table A10.65b Hypothesis tests PG Cohort 2 of gender differences in the importance of existing knowledge.

Knowledge Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Accounting and Finance	.961	.485	Moderately more significant
Sales and Marketing	.163	.239	Slightly less significant
Human Resource Management	.080	.255	Moderately less significant
Project planning	.524	.270	Moderately more significant
Design and Production	.784	.675	Slightly more significant
Quality Management	.709	.964	Moderately less significant
Legal aspects	.742	.364	Moderately more significant

Table A10.66a Hypothesis tests PG Cohort 1 of gender differences in the importance of existing skills.

Skill Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Give effective presentations	.877	.160	Highly more significant
Produce quality reports	.641	.860	Moderately less significant
Be creative	.569	.176	Moderately more significant
Solve problems	1.000	.596	Moderately more significant
Formulate good questions	.436	.527	Slightly less significant
Work effectively in a team	.377	.322	Very slightly more significant
Design & produce products/services	.769	.118	Highly more significant
Communicate effectively	.743	.232	Highly more significant
Use discussion to investigate issues	.796	.705	Very slightly more significant
Opportunity to Improve	.959	.820	Slightly more significant

Table A10.66b Hypothesis tests PG Cohort 2 of gender differences of the importance of existing skills.

Skill Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Give effective presentations	.685	.788	Slightly less significant
Produce quality reports	.513	.394	Slightly more significant
Be creative	.944	.375	Highly more significant
Solve problems	.906	.533	Moderately more significant
Formulate good questions	.969	.758	Moderately more significant
Work effectively in a team	.774	.885	Slightly less significant
Design & produce products/services	.992	.286	Highly more significant
Communicate effectively	.227	.724	Highly less significant
Use discussion to investigate issues	.250	.468	Moderately less significant
Opportunity to Improve	.252	.286	Slightly less significant

Table A10.67a Hypothesis tests PG Cohort 1 of gender differences in self-esteem.

Self-Esteem Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Problem solving	.616	.705	Slightly less significant
Getting resources	.769	.495	Moderately more significant
Achieving aims/goals	.138	.596	Moderately less significant
Deal with unexpected events	.396	.348	Very slightly more significant
Resourcefulness	.007	.433	Moderately less significant
Relying on oneself	.066	.980	Highly less significant
Investing the appropriate effort	.217	.275	Slightly less significant
Sticking to my plans	.027	.495	Moderately less significant
Being calm under stress	.478	.781	Moderately less significant
Generating solutions to problems	.290	.403	Slightly less significant
Coping with uncertainty	.148	.781	Highly less significant
Acceptance of challenges	.274	.781	Highly less significant
Thinking around a problem	.259	.403	Moderately less significant
Making sensible judgments	.245	.403	Moderately less significant
Sticking to my plans 2	.020	.596	Moderately less significant

Table A10.67b Hypothesis tests PG Cohort 2 of gender differences in self-esteem.

Self-Esteem Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Problem solving	.197	.180	Very slightly more significant
Getting resources	.928	.758	Moderately more significant
Achieving aims/goals	.117	.004	Moderately more significant
Deal with unexpected events	.549	.625	Slightly less significant
Resourcefulness	.780	.262	Highly more significant
Relying on oneself	.598	.228	Moderately more significant
Investing the appropriate effort	.266	.630	Moderately less significant
Sticking to my plans	1.000	.697	Moderately more significant
Being calm under stress	.686	.849	Moderately less significant
Generating solutions to problems	.321	.457	Slightly less significant
Coping with uncertainty	.879	.766	Moderately more significant
Acceptance of challenges	.787	.693	Slightly more significant
Thinking around a problem	.544	.680	Moderately less significant
Making sensible judgments	.364	.603	Moderately less significant
Sticking to my plans 2	.985	.857	Slightly more significant

Table A10.68a Hypothesis tests PG Cohort 1 of gender differences in self-efficacy.

Self-Efficacy Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
Finish reports or assignments on time	.169	.980	Very highly less significant
Concentrate on technical engineering subjects	.097	.495	Moderately less significant
Take class notes that will be useful in technical or engineering projects	.259	.781	Highly less significant
Use the library and search engines for engineering research	.204	.495	Moderately less significant
Plan and organise your workload and technical study space	.129	.631	Highly less significant
Remember 'Engineering Design' lecture content	.017	.298	Moderately less significant
Remember 'Engineering Design' practical session outputs	.061	.743	Highly less significant
Motivate yourself to study engineering	.641	.743	Slightly less significant
Take part in class based engineering or technical discussions	.231	.596	Moderately less significant
Review instructions and estimate how long it will take to complete an engineering task	.204	.375	Slightly less significant
Design and construct an experiment that maintains precisely specified conditions	.129	.375	Slightly less significant
Lead a technical team to develop a new product to a successful result	.323	1.000	Highly less significant
Document technical procedures so that someone else could use them to produce the same result	.090	.463	Moderately less significant
Write a clear and concise engineering project plan	.097	.561	Moderately less significant

Table A10.68b Hypothesis tests PG Cohort 2 of gender differences in self-efficacy.

Self-Efficacy Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Finish reports or assignments on time	.545	.160	Moderately more significant
Concentrate on technical engineering subjects	.778	.240	Highly more significant
Take class notes that will be useful in technical or engineering projects	.316	.670	Moderately less significant
Use the library and search engines for engineering research	.106	.939	Highly less significant
Plan and organise your workload and technical study space	.325	.863	Highly less significant
Remember 'Engineering Design' lecture content	.300	.752	Moderately less significant
Remember 'Engineering Design' practical session outputs	.529	.332	Moderately more significant
Motivate yourself to study engineering	.426	.670	Moderately less significant
Take part in class based engineering or technical discussions	.004	.136	Moderately less significant
Review instructions and estimate how long it will take to complete an engineering task	.060	.194	Moderately less significant
Design and construct an experiment that maintains precisely specified conditions	.014	.916	Highly less significant
Lead a technical team to develop a new product to a successful result	.082	.323	Moderately less significant
Document technical procedures so that someone else could use them to produce the same result	.018	.296	Moderately less significant
Write a clear and concise engineering project plan	.173	.239	Slightly less significant

Table A10.69a Hypothesis tests PG Cohort 1 of gender differences in preferred learning style.

Learning Style Category Item	Mann-Whitney U		Tendency
	Pre	Post	
When I operate new equipment I generally	.306	.495	Moderately less significant
If I am going somewhere new and need directions I usually	.545	.275	Moderately more significant
If I am cooking a new dish I generally	.849	.194	Highly more significant
If I am teaching someone something new I tend to	.377	.375	Virtually unchanged
In general conversation I would tend to say	.306	.940	Highly more significant
During my free time I would rather	.180	.900	Highly less significant
If I were choosing a holiday I would prefer to	.877	.275	Highly more significant
If I were out shopping for clothes I would tend to	.796	.916	Moderately less significant
When I concentrate, I most often	.217	.298	Slightly less significant
When I am learning a new skill I feel most comfortable when	.796	.253	Moderately more significant

Table A10.69b Hypothesis tests PG Cohort 2 of gender differences in preferred learning style.

Learning Style Category Item	Mann-Whitney U		Tendency
	Pre	Post	
When I operate new equipment I generally	.658	.124	Moderately more significant
If I am going somewhere new and need directions I usually	.686	.970	Moderately less significant
If I am cooking a new dish I generally	.003	.250	Moderately less significant
If I am teaching someone something new I tend to	.767	.608	Slightly more significant
In general conversation I would tend to say	.021	.798	Highly less significant
During my free time I would rather	.010	.015	Virtually unchanged
If I were choosing a holiday I would prefer to	.775	.301	Moderately more significant
If I were out shopping for clothes I would tend to	.418	.208	Moderately more significant
When I concentrate, I most often	.188	.136	Slightly more significant
When I am learning a new skill I feel most comfortable when	.493	.331	Moderately more significant

Table A10.70a Postgraduate responses of the importance of existing knowledge split by age and data collection Cohort 1.

Tests of Normality				
	Age at last birthday	Shapiro-Wilk		
		Statistic	df	Sig.
Accounting & Finance Pre	18-24	.741	20	.000
	25-34	.827	6	.101
Accounting & Finance Post	18-24	.780	20	.000
	25-34	.640	6	.001
Sales and Marketing Pre	18-24	.814	20	.001
	25-34	.770	6	.031
Sales and Marketing Post	18-24	.797	20	.001
	25-34	.683	6	.004
Human Resource Management Pre	18-24	.788	20	.001
	25-34	.770	6	.031
Human Resource Management Post	18-24	.798	20	.001
	25-34	.866	6	.212
Project planning Pre	18-24	.559	20	.000
	25-34	.770	6	.031
Project planning Post	18-24	.780	20	.000
	25-34	.866	6	.212
Design and Production Pre	18-24	.842	20	.004
	25-34	.822	6	.091
Design and Production Post	18-24	.798	20	.001
	25-34	.866	6	.212
Quality Management Pre	18-24	.668	20	.000
	25-34	.866	6	.212
Quality Management Post	18-24	.744	20	.000
	25-34	.496	6	.000
Legal aspects Pre	18-24	.763	20	.000
	25-34	.831	6	.110
Legal aspects Post	18-24	.762	20	.000
	25-34	.853	6	.167

Table A10.70b Postgraduate responses of the importance of existing knowledge split by age and data collection Cohort 2.

Tests of Normality				
	Age at last birthday	Shapiro-Wilk		
		Statistic	df	Sig.
Accounting & Finance Pre	18-24	.765	42	.000
	25-34	.564	9	.000
Accounting & Finance Post	18-24	.576	40	.000
	25-34	.763	9	.008
Sales and Marketing Pre	18-24	.805	42	.000
	25-34	.655	9	.000
Sales and Marketing Post	18-24	.822	40	.000
	25-34	.833	9	.049
Human Resource Management Pre	18-24	.800	42	.000
	25-34	.617	9	.000
Human Resource Management Post	18-24	.808	40	.000
	25-34	.617	9	.000
Project planning Pre	18-24	.586	42	.000
	25-34	.617	9	.000
Project planning Post	18-24	.539	40	.000
	25-34	.390	9	.000
Design and Production Pre	18-24	.766	42	.000
	25-34	.813	9	.028
Design and Production Post	18-24	.770	40	.000
	25-34	.617	9	.000
Quality Management Pre	18-24	.703	42	.000
	25-34	.655	9	.000
Quality Management Post	18-24	.720	40	.000
	25-34	.655	9	.000
Legal aspects Pre	18-24	.722	42	.000
	25-34	.684	9	.001
Legal aspects Post	18-24	.760	40	.000
	25-34	.617	9	.000

Table A10.71a Normality tests Cohort 1 of the importance of skills split by age.

Tests of Normality							
	Age at last birthday	Shapiro-Wilk Pre			Shapiro-Wilk Post		
		Statistic	df	Sig.	Statistic	df	Sig.
Give effective presentations Pre	18-24	.750	20	.000		20	.000
	25-34	.908	6	.421		6	.001
Produce quality reports Pre	18-24	.761	20	.000		20	.003
	25-34	.960	6	.820		6	.001
Be creative Pre	18-24	.792	20	.001		20	.011
	25-34	.683	6	.004		6	.004
Solve problems Pre	18-24	.643	20	.000		20	.000
	25-34	.773	6	.033		6	.101
Formulate good questions Pre	18-24	.895	20	.033		20	.001
	25-34	.866	6	.212		6	.167
Work effectively in a team Pre	18-24	.758	20	.000		20	.000
	25-34	.770	6	.031		6	.000
Design and produce products/services Pre	18-24	.906	20	.053		20	.000
	25-34	.866	6	.212		6	.000
Communicate effectively Pre	18-24	.698	20	.000		20	.000
	25-34	.822	6	.091		6	.000
Use discussion to investigate an issue Pre	18-24	.849	20	.005		20	.000
	25-34	.866	6	.212		6	.101

Table A10.71b PG responses of the importance of skills split by age and data collection Cohort 2.

Tests of Normality							
	Age at last birthday	Shapiro-Wilk Pre			Shapiro-Wilk Post		
		Statistic	df	Sig.	Statistic	df	Sig.
Give effective presentations	18-24	.722	42	.000	.758	40	.000
	25-34	.655	9	.000	.617	9	.000
Produce quality reports	18-24	.700	42	.000	.752	40	.000
	25-34	.805	9	.024	.655	9	.000
Be creative	18-24	.711	42	.000	.773	40	.000
	25-34	.655	9	.000	.655	9	.000
Solve problems	18-24	.611	42	.000	.576	40	.000
	25-34	.617	9	.000	.617	9	.000
Formulate good questions	18-24	.798	42	.000	.794	40	.000
	25-34	.763	9	.008	.655	9	.000
Work effectively in a team	18-24	.621	42	.000	.648	40	.000
	25-34	.655	9	.000	.564	9	.000
Design & produce products/services	18-24	.821	42	.000	.810	40	.000
	25-34	.823	9	.037	.805	9	.024
Communicate effectively	18-24	.811	42	.000	.614	40	.000
	25-34	.808	9	.025	.655	9	.000
Use discussion to investigate issues	18-24	.685	39	.000	.763	40	.000
	25-34	.822	6	.091	.781	9	.012

Table A10.72 Postgraduate responses of the importance of improvement split by age both Cohorts.

Tests of Normality							
	Age at last birthday	Shapiro-Wilk Pre/3			Shapiro-Wilk Post/4		
		Statistic	df	Sig.	Statistic	df	Sig.
IMPROVE_Cohort 1	18-24	.433	20	.000	.626	20	.000
	25-34	.683	6	.004	.640	6	.001
IMPROVE_Cohort 2	18-24	.685	39	.000	.644	40	.000
	25-34	.822	6	.091	.418	8	.000

Table A10.73a Normality tests in the Self-Esteem category split by age Cohort 1.

Tests of Normality

	Age at last birthday	Shapiro-Wilk Pre Statistic	df	Sig.	Shapiro-Wilk Post Statistic	df	Sig.
Problem solving	18-24	.780	20	.000	.754	20	.000
	25-34	.866	6	.212	.640	6	.001
Getting resources	18-24	.760	20	.000	.812	20	.001
	25-34	.640	6	.001	.827	6	.101
Achieving aims/goals	18-24	.723	20	.000	.728	20	.000
	25-34	.701	6	.006	.866	6	.212
Deal with unexpected events	18-24	.868	20	.011	.790	20	.001
	25-34	.640	6	.001	.827	6	.101
Resourcefulness	18-24	.829	20	.002	.768	20	.000
	25-34	.640	6	.001	.496	6	.000
Relying on oneself	18-24	.865	20	.010	.821	20	.002
	25-34	.866	6	.212	.827	6	.101
Investing the appropriate effort	18-24	.661	20	.000	.641	20	.000
	25-34	.640	6	.001	.866	6	.212
Sticking to my plans	18-24	.778	20	.000	.675	20	.000
	25-34	.822	6	.091	.866	6	.212
Being calm under stress	18-24	.880	20	.018	.788	20	.001
	25-34	.640	6	.001	.805	6	.065
Generating solutions to problems	18-24	.805	6	.065	.822	6	.091
	25-34	.826	20	.002	.815	20	.001
Coping with uncertainty	18-24	.496	6	.000	.640	6	.001
	25-34	.855	20	.006	.795	20	.001
Acceptance of challenges	18-24	.773	20	.000	.695	20	.000
	25-34	.866	6	.212	.496	6	.000
Thinking around a problem	18-24	.863	20	.009	.672	20	.000
	25-34	.496	6	.000	.683	6	.004
Making sensible judgments	18-24	.875	20	.015	.803	20	.001
	25-34	.683	6	.004	.640	6	.001
Sticking to my plans 2	18-24	.870	20	.012	.835	20	.003
	25-34	.907	6	.415	.683	6	.004

Table A10.73b Normality tests in the Self-Esteem category split by age Cohort 2.

Tests of Normality

	Age at last birthday	Shapiro-Wilk Pre Statistic	df	Sig.	Shapiro-Wilk Post Statistic	df	Sig.
Problem solving	18-24	.760	42	.000	.331	40	.000
	25-34	.536	9	.000	.748	9	.005
Getting resources	18-24	.765	42	.000	.744	40	.000
	25-34	.805	9	.024	.805	9	.024
Achieving aims/goals	18-24	.818	42	.000	.864	40	.000
	25-34	.813	9	.028	.684	9	.001
Deal with unexpected events	18-24	.845	42	.000	.868	40	.000
	25-34	.536	9	.000	.781	9	.012
Resourcefulness	18-24	.823	42	.000	.812	40	.000
	25-34	.655	9	.000	.813	9	.028
Relying on oneself	18-24	.863	42	.000	.894	40	.001
	25-34	.752	9	.006	.637	9	.000
Investing the appropriate effort	18-24	.732	42	.000	.623	40	.000
	25-34	.728	9	.003	.655	9	.000
Sticking to my plans	18-24	.816	42	.000	.833	40	.000
	25-34	.941	9	.595	.658	9	.000
Being calm under stress	18-24	.797	42	.000	.810	40	.000
	25-34	.781	9	.012	.838	9	.055
Generating solutions to problems	18-24	.825	42	.000	.836	40	.000
	25-34	.390	9	.000	.536	9	.000
Coping with uncertainty	18-24	.759	42	.000	.866	40	.000
	25-34	.781	9	.012	.781	9	.012
Acceptance of challenges	18-24	.857	42	.000	.894	40	.001
	25-34	.813	9	.028	.913	9	.338
Thinking around a problem	18-24	.648	42	.000	.555	40	.000
	25-34	.536	9	.000	.536	9	.000
Making sensible judgments	18-24	.858	42	.000	.787	40	.000
	25-34	.781	9	.012	.564	9	.000
Sticking to my plans 2	18-24	.908	42	.003	.859	40	.000
	25-34	.833	9	.049	.805	9	.024

Table A10.74a Normality tests in the Self-Efficacy category split by age Cohort 1.

Tests of Normality

	Age at last birthday	Shapiro-Wilk Pre			Shapiro-Wilk Post		
		Statistic	df	Sig.	Statistic	df	Sig.
Finish reports or assignments on time	18-24	.784	20	.000	.800	20	.001
	25-34	.683	6	.004	.827	6	.101
Concentrate on technical engineering subjects	18-24	.800	20	.001	.754	20	.000
	25-34	.827	6	.101	.827	6	.101
Take class notes that will be useful in technical or engineering projects	18-24	.762	20	.000	.856	20	.007
	25-34	.683	6	.004	.640	6	.001
Use the library and search engines for engineering research	18-24	.701	20	.000	.838	20	.003
	25-34	.866	6	.212	.853	6	.167
Plan and organise your workload and technical study space	18-24	.862	20	.009	.754	20	.000
	25-34	.866	6	.212	.866	6	.212
Remember 'Engineering Design' lecture content	18-24	.879	20	.017	.809	20	.001
	25-34	.683	6	.004	.853	6	.167
Remember 'Engineering Design' practical session outputs	18-24	.798	20	.001	.754	20	.000
	25-34	.683	6	.004	.496	6	.000
Motivate yourself to study engineering	18-24	.768	20	.000	.767	20	.000
	25-34	.866	6	.212	.496	6	.000
Take part in class based engineering or technical discussions	18-24	.800	20	.001	.812	20	.001
	25-34	.822	6	.091	.822	6	.091
Review instructions and estimate how long it will take to complete an engineering task	18-24	.771	20	.000	.807	20	.001
	25-34	.827	6	.101	.496	6	.000
Design and construct an experiment that maintains precisely specified conditions	18-24	.879	20	.017	.812	20	.001
	25-34	.683	6	.004	.640	6	.001
Lead a technical team to develop a new product to a successful result	18-24	.915	20	.078	.813	20	.001
	25-34	.683	6	.004	.496	6	.000
Document technical procedures so that someone else could use them to produce the same result	18-24	.759	20	.000	.784	20	.000
	25-34	.960	6	.820	.496	6	.000
Write a clear and concise engineering project plan	18-24	.800	20	.001	.856	20	.007
	25-34	.827	6	.101	.827	6	.101

Table A10.74b Normality tests in the Self-Efficacy category split by age Cohort 2.

Tests of Normality

	Age at last birthday	Shapiro-Wilk Pre Statistic	df	Sig.	Shapiro-Wilk Post Statistic	df	Sig.
Finish reports or assignments on time	18-24	.748	42	.000	.754	40	.000
	25-34	.564	9	.000	.684	9	.001
Concentrate on technical engineering subjects	18-24	.791	42	.000	.830	40	.000
	25-34	.748	9	.005	.805	9	.024
Take class notes that will be useful in technical or engineering projects	18-24	.742	42	.000	.866	40	.000
	25-34	.763	9	.008	.781	9	.012
Use the library and search engines for engineering research	18-24	.751	42	.000	.789	40	.000
	25-34	.617	9	.000	.655	9	.000
Plan and organise your workload and technical study space	18-24	.785	42	.000	.805	40	.000
	25-34	.748	9	.005	.808	9	.025
Remember 'Engineering Design' lecture content	18-24	.833	42	.000	.874	39	.000
	25-34	.838	9	.055	.833	9	.049
Remember 'Engineering Design' practical session outputs	18-24	.859	42	.000	.874	39	.000
	25-34	.833	9	.049	.813	9	.028
Motivate yourself to study engineering	18-24	.731	42	.000	.800	40	.000
	25-34	.805	9	.024	.760	9	.007
Take part in class based engineering or technical discussions	18-24	.769	42	.000	.783	40	.000
	25-34	.838	9	.055	.808	9	.025
Review instructions and estimate how long it will take to complete an engineering task	18-24	.814	42	.000	.819	40	.000
	25-34	.780	9	.012	.813	9	.028
Design and construct an experiment that maintains precisely specified conditions	18-24	.841	42	.000	.879	40	.000
	25-34	.780	9	.012	.873	9	.132
Lead a technical team to develop a new product to a successful result	18-24	.856	42	.000	.861	39	.000
	25-34	.874	9	.136	.838	9	.055
Document technical procedures so that someone else could use them to produce the same result	18-24	.806	42	.000	.860	40	.000
	25-34	.833	9	.049	.833	9	.049
Write a clear and concise engineering project plan	18-24	.846	42	.000	.818	40	.000
	25-34	.903	9	.273	.655	9	.000

Table A10.75a Postgraduate responses of their learning preference (VAK) split by age Cohort 1.

Tests of Normality							
	Age at last birthday	Shapiro-Wilk Pre			Shapiro-Wilk Post		
		Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	18-24	.788	19	.001	.583	19	.000
	25-34	.552	5	.000	.552	5	.000
If I am going somewhere new and need directions I usually	18-24	.362	19	.000	.647	19	.000
	25-34	Null	Null	Null	.552	5	.000
If I am cooking a new dish I generally	18-24	.696	19	.000	.775	19	.001
	25-34	.552	5	.000	.881	5	.314
If I am teaching someone something new I tend to	18-24	.793	19	.001	.788	19	.001
	25-34	.883	5	.325	.684	5	.006
In general conversation I would tend to say	18-24	.795	19	.001	.749	19	.000
	25-34	.883	5	.325	.552	5	.000
During my free time I would rather	18-24	.803	19	.001	.745	19	.000
	25-34	.881	5	.314	.684	5	.006
If I were choosing a holiday I would prefer to	18-24	.775	19	.001	.765	19	.000
	25-34	.883	5	.325	.684	5	.006
If I were out shopping for clothes I would tend to	18-24	.519	19	.000	.690	19	.000
	25-34	.552	5	.000	.552	5	.000
When I concentrate, I most often	18-24	.796	19	.001	.796	19	.001
	25-34	.771	5	.046	.684	5	.006
When I am learning a new skill I feel most comfortable when	18-24	.700	19	.000	.722	19	.000
	25-34	.684	5	.006	.552	5	.000

Table A10.75b Postgraduate responses of their learning preference (VAK) split by age Cohort 2.

Tests of Normality							
		Shapiro-Wilk Pre			Shapiro-Wilk Post		
	Age	Statistic	df	Sig.	Statistic	df	Sig.
When I operate new equipment I generally	18-24	.614	41	.000	.686	40	.000
	25-34	.564	9	.000	.564	9	.000
If I am going somewhere new and need directions I usually	18-24	.475	41	.000	.399	40	.000
If I am cooking a new dish I generally	18-24	.756	41	.000	.694	40	.000
	25-34	.658	9	.000	.780	9	.012
If I am teaching someone something new I tend to	18-24	.783	41	.000	.793	40	.000
	25-34	.838	9	.055	.617	9	.000
In general conversation, I would tend to say	18-24	.755	41	.000	.784	40	.000
	25-34	.781	9	.012	.838	9	.055
During my free time, I would rather	18-24	.780	41	.000	.721	40	.000
	25-34	.655	9	.000	.780	9	.012
If I were choosing a holiday I would prefer to	18-24	.794	41	.000	.801	40	.000
	25-34	.838	9	.055	.833	9	.049
If I were out shopping for clothes I would tend to	18-24	.460	41	.000	.428	40	.000
When I concentrate, I most often	18-24	.647	41	.000	.771	40	.000
	25-34	.781	9	.012	.838	9	.055
When I am learning a new skill, I feel most comfortable when	18-24	.534	41	.000	.701	40	.000
	25-34	.748	9	.005	.658	9	.000

Table A10.76a – Non-parametric significance tests (2-tailed)- Knowledge Category

Importance of Knowledge Category	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Accounting and Finance	.148	.705	.118	.543
Sales and Marketing	.180	.874	.161	.776
Human Resource Management	.791	.723	.887	.636
Project planning	.771	.072	.688	.070
Design and Production	.138	.011	.118	.010
Quality Management	.598	.480	.503	.392
Legal aspects	.281	.769	.195	.878

Table A10.76b – Non-parametric significance tests (2-tailed)- Skill Category

Importance of Skills and the Opportunity to Improve Categories	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Give effective presentations	.509	.669	.406	.583
Produce quality Reports	.078	.242	.078	.227
Be creative	.657	.553	.556	.868
Solve problems	.556	.491	.466	.420
Formulate good Questions	.089	.579	.078	.472
Work effectively in a team	.153	.848	.161	.772
Design & produce products/services	.185	.142	.164	.117
Communicate Effectively	.058	.683	.051	.583
Use discussion to investigate issues	.171	.485	.161	.481
Opportunity to Improve	.157	.368	.161	.430

Table A10.76c – Non-parametric significance tests (2-tailed)- Self-Esteem Category

Self Esteem Category	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Problem solving	.071	.396	.071	.238
Getting resources	.012	.896	.010	1.000
Achieving aims/goals	.016	.476	.013	.499
Deal with unexpected events	.010	.770	.009	.749
Resourcefulness	.007	.329	.004	.302
Relying on oneself	.036	.976	.030	.916
Investing the appropriate effort	.007	.135	.008	.212
Sticking to my plans	.002	.178	.001	.147
Being calm under stress	.034	.919	.025	1.000
Generating solutions to problems	.109	.036	.110	.032
Coping with uncertainty	.001	.670	.001	.685
Acceptance of challenges	.011	.664	.008	.613
Thinking around a problem	.216	1.000	.199	1.000
Making sensible judgments	.040	.734	.037	.772
Sticking to my plans 2	.041	.890	.039	.811

Table A10.76d – Non-parametric significance tests (2-tailed)- Self-Efficacy Category

Self Efficacy Category	**Wilcoxon Signed Rank Test**		**Paired Sample Tests**	
	Cohort 1	**Cohort 2**	**Cohort 1**	**Cohort 2**
Finish reports or assignments on time	.406	.572	.476	.583
Concentrate on technical engineering subjects	.122	.257	.118	.336
Take class notes that will be useful in technical or engineering projects	.010	.001	.008	.001
Use the library and search engines for engineering research	.041	.257	.039	.227
Plan and organise your workload and technical study space	.134	.670	.133	.636
Remember 'Engineering Design' lecture content	.035	.290	.030	.309
Remember 'Engineering Design' practical session outputs	.007	.239	.004	.244
Motivate yourself to study engineering	.378	.130	.381	.124
Take part in class based engineering or technical discussions	.617	.858	.626	.860
Review instructions and estimate how long it will take to complete an engineering task	.356	.978	.404	.803
Design and construct an experiment that maintains precisely specified conditions	.031	.125	.025	.109
Lead a technical team to develop a new product to a successful result	.005	.486	.002	.441
Document technical procedures so that someone else could use them to produce the same result	.001	.161	.000	.160
Write a clear and concise engineering project plan	.320	.057	.327	.057

Table A10.76e – Non-parametric significance tests (2-tailed)- Learning Style Category

Learning Style Preference Category	Wilcoxon Signed Rank Test		Paired Sample Tests	
	Cohort 1	Cohort 2	Cohort 1	Cohort 2
When I operate new equipment I generally	.013	.808	.010	.864
If I am going somewhere new and need directions I usually	.145	.792	.136	.785
If I am cooking a new dish I generally	.509	.751	.523	.767
If I am teaching someone something new I tend to	.822	.572	.823	.583
In general conversation I would tend to say	.039	.489	.036	.511
During my free time I would rather	.107	.499	.110	.519
If I were choosing a holiday I would prefer to	.602	.912	.746	1.000
If I were out shopping for clothes I would tend to	.317	.665	.327	.821
When I concentrate, I most often	.981	.201	1.000	.204
When I am learning a new skill I feel most comfortable when	.623	.201	.646	.183

Table A10.77a Hypothesis tests PG Cohort 1 of differences in the importance of knowledge by previous education.

Knowledge Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Accounting and Finance	.377	.208	Slightly more significant
Sales and Marketing	.545	.845	Moderately less significant
Human Resource Management	.823	.639	Moderately more significant
Project planning	.691	.327	Moderately more significant
Design and Production	.500	.611	Slightly less significant
Quality Management	.666	.876	Moderately less significant
Legal aspects	.323	.725	Highly less significant

Table A10.77b Hypothesis tests PG Cohort 2 of differences in the importance of knowledge by previous education.

Knowledge Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Accounting and Finance	.531	.352	Moderately more significant
Sales and Marketing	.181	.754	Highly less significant
Human Resource Management	.767	.606	Moderately more significant
Project planning	.643	.853	Moderately less significant
Design and Production	.024	.171	Moderately less significant
Quality Management	.581	.394	Moderately more significant
Legal aspects	.464	.492	Virtually unchanged

Table 10.78a Hypothesis tests PG Cohort 1 of differences in the importance of skills by previous education.

Skill Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Give effective presentations	.769	.611	Slightly more significant
Produce quality reports	.796	.271	Highly more significant
Be creative	.377	.506	Slightly less significant
Solve problems	.500	.271	Moderately more significant
Formulate good questions	.823	.457	Moderately more significant
Work effectively in a team	.569	.481	Slightly more significant
Design & produce products/services	.522	.938	Highly less significant
Communicate effectively	.931	.785	Slightly more significant
Use discussion to investigate issues	.290	.907	Highly less significant

Table A10.78b Hypothesis tests PG Cohort 2 of differences in the importance of skills by previous education.

Skill Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Give effective presentations	.521	.754	Moderately less significant
Produce quality reports	.194	.714	Highly less significant
Be creative	.414	.185	Moderately more significant
Solve problems	.991	.478	Highly more significant
Formulate good questions	.949	.964	Virtually unchanged
Work effectively in a team	.543	.745	Moderately less significant
Design & produce products/services	.061	.612	Highly less significant
Communicate effectively	.823	.742	Slightly more significant
Use discussion to investigate issues	.219	.668	Moderately less significant

Table A10.79a Hypothesis tests PG Cohort 1 of differences in self-esteem by previous education.

Self-Esteem Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Problem solving	.478	.725	Moderately less significant
Getting resources	.823	.307	Highly more significant
Achieving aims/goals	.691	.667	Virtually unchanged
Deal with unexpected events	.169	.133	Virtually unchanged
Resourcefulness	.120	.307	Moderately less significant
Relying on oneself	.986	1.000	Virtually unchanged
Investing the appropriate effort	.959	.815	Slightly more significant
Sticking to my plans	.148	.907	Highly less significant
Being calm under stress	.148	.289	Slightly less significant
Generating solutions to problems	.796	.938	Slightly less significant
Coping with uncertainty	.169	.180	Virtually unchanged
Acceptance of challenges	.066	.845	Highly less significant
Thinking around a problem	.014	.584	Highly less significant
Making sensible judgments	.986	.347	Highly more significant
Sticking to my plans 2	.323	.506	Moderately less significant

Table A10.79b Hypothesis tests PG Cohort 2 of differences in self-esteem by previous education.

Self-Esteem Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Problem solving	.899	.451	Moderately more significant
Getting resources	.791	.011	Highly more significant
Achieving aims/goals	.161	.202	Slightly less significant
Deal with unexpected events	.528	.553	Virtually unchanged
Resourcefulness	.126	.665	Moderately less significant
Relying on oneself	.105	.965	Very highly less significant
Investing the appropriate effort	.357	.846	Moderately less significant
Sticking to my plans	.096	.206	Slightly less significant
Being calm under stress	.134	.738	Highly less significant
Generating solutions to problems	.090	.096	Virtually unchanged
Coping with uncertainty	.002	.236	Moderately less significant
Acceptance of challenges	.262	.362	Slightly less significant
Thinking around a problem	.367	.906	Moderately less significant
Making sensible judgments	.820	.971	Slightly less significant
Sticking to my plans 2	.749	.239	Moderately more significant

Table A10.80a Hypothesis tests PG Cohort 1 of differences in self-efficacy by previous education.

Self-Efficacy Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Finish reports or assignments on time	.090	.531	Highly less significant
Concentrate on technical engineering subjects	.112	.755	Highly less significant
Take class notes that will be useful in technical or engineering projects	.030	.938	Very highly less significant
Use the library and search engines for engineering research	.457	.584	Slightly less significant
Plan and organise your workload and technical study space	.017	.876	Very highly less significant
Remember 'Engineering Design' lecture content	.204	.815	Highly less significant
Remember 'Engineering Design' practical session outputs	.025	.876	Very highly less significant
Motivate yourself to study engineering	1.000	.307	Highly more significant
Take part in class based engineering or technical discussions	.796	.133	Highly more significant
Review instructions and estimate how long it will take to complete an engineering task	.457	.238	Slightly more significant
Design and construct an experiment that maintains precisely specified conditions	.231	.238	Virtually unchanged
Lead a technical team to develop a new product to a successful result	.083	.289	Moderately less significant
Document technical procedures so that someone else could use them to produce the same result	.217	.223	Virtually unchanged
Write a clear and concise engineering project plan	.545	.876	Moderately less significant

Table A10.80b Hypothesis tests PG Cohort 2 of differences in self-efficacy by previous education.

Self-Efficacy Category Item	Mann-Whitney U		Tendency
	Pre	Post	
Finish reports or assignments on time	.721	.038	Highly more significant
Concentrate on technical engineering subjects	.246	.451	Moderately less significant
Take class notes that will be useful in technical or engineering projects	.956	.904	Virtually unchanged
Use the library and search engines for engineering research	.698	.045	Highly more significant
Plan and organise your workload and technical study space	.084	.965	Very highly less significant
Remember 'Engineering Design' lecture content	.705	.167	Highly more significant
Remember 'Engineering Design' practical session outputs	.463	.702	Moderately less significant
Motivate yourself to study engineering	.892	.603	Moderately more significant
Take part in class based engineering or technical discussions	.247	.345	Slightly less significant
Review instructions and estimate how long it will take to complete an engineering task	.613	1.000	Moderately less significant
Design and construct an experiment that maintains precisely specified conditions	.864	.198	Highly more significant
Lead a technical team to develop a new product to a successful result	.772	.055	Highly more significant
Document technical procedures so that someone else could use them to produce the same result	.783	.548	Moderately more significant
Write a clear and concise engineering project plan	.065	.016	Slightly more significant

Table A10.81a Hypothesis tests PG Cohort 1 of differences in preferred learning style by previous education.

Learning Style Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
When I operate new equipment I generally	.743	.950	Moderately less significant
If I am going somewhere new and need directions I usually	.545	.208	Moderately more significant
If I am cooking a new dish I generally	.641	.144	Moderately more significant
If I am teaching someone something new I tend to	.904	.194	Very highly more significant
In general conversation I would tend to say	.569	.327	Moderately more significant
During my free time I would rather	.592	.755	Moderately less significant
If I were choosing a holiday I would prefer to	.061	1.000	Highly less significant
If I were out shopping for clothes I would tend to	.691	.724	Slightly less significant
When I concentrate, I most often	.616	.531	Slightly more significant
When I am learning a new skill I feel most comfortable when	.717	.238	Moderately more significant

Table A10.81b Hypothesis tests PG Cohort 2 of differences in preferred learning style by previous education.

Learning Style Category Item	**Mann-Whitney U**		**Tendency**
	Pre	**Post**	
When I operate new equipment I generally	.339	.163	Moderately more significant
If I am going somewhere new and need directions I usually	.222	.723	Moderately less significant
If I am cooking a new dish I generally	.740	.359	Moderately more significant
If I am teaching someone something new I tend to	.248	.219	Slightly more significant
In general conversation I would tend to say	.347	.006	Highly more significant
During my free time I would rather	.701	.801	Slightly less significant
If I were choosing a holiday I would prefer to	.130	.777	Highly less significant
If I were out shopping for clothes I would tend to	.176	.963	Very highly less significant
When I concentrate, I most often	.119	.528	Moderately less significant
When I am learning a new skill I feel most comfortable when	.850	.200	Highly more significant

Table A10.82 Postgraduate importance of knowledge – inter-item correlation matrix Cohort 1

Inter-Item Correlation Matrix Pre							
	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.723	.674	.781	.416	.712	.732
Sales and Marketing	.723	1.000	.770	.699	.585	.690	.808
Human Resource Management	.674	.770	1.000	.709	.586	.779	.808
Project planning	.781	.699	.709	1.000	.557	.824	.812
Design and Production	.416	.585	.586	.557	1.000	.704	.640
Quality Management	.712	.690	.779	.824	.704	1.000	.843
Legal aspects	.732	.808	.808	.812	.640	.843	1.000

Inter-Item Correlation Matrix Post							
	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.500	.576	.350	.352	.264	.542
Sales and Marketing	.500	1.000	.290	.388	.415	.400	.155
Human Resource Management	.576	.290	1.000	.359	.308	.314	.596
Project planning	.350	.388	.359	1.000	.370	.712	.569
Design and Production	.352	.415	.308	.370	1.000	.382	.425
Quality Management	.264	.400	.314	.712	.382	1.000	.520
Legal aspects	.542	.155	.596	.569	.425	.520	1.000

Table A10.83 Postgraduate importance of knowledge – inter-item correlation matrix Cohort 2

Inter-Item Correlation Matrix Pre

	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.719	.546	.516	.455	.423	.618
Sales and Marketing	.719	1.000	.706	.452	.512	.458	.738
Human Resource Management	.546	.706	1.000	.585	.519	.508	.541
Project planning	.516	.452	.585	1.000	.541	.631	.572
Design and Production	.455	.512	.519	.541	1.000	.507	.342
Quality Management	.423	.458	.508	.631	.507	1.000	.575
Legal aspects	.618	.738	.541	.572	.342	.575	1.000

Inter-Item Correlation Matrix Post

	Acc & Fin	Sales and Mkt	HR Mgmt	Proj plan	Des and Prod	Qual Mgmt	Legal Aspect
Accounting & Finance	1.000	.324	-.010	.145	.162	.019	.141
Sales and Marketing	.324	1.000	.168	.152	.068	.247	.106
Human Resource Management	-.010	.168	1.000	.075	.041	.239	-.008
Project planning	.145	.152	.075	1.000	.260	.092	.047
Design and Production	.162	.068	.041	.260	1.000	.302	.080
Quality Management	.019	.247	.239	.092	.302	1.000	.325
Legal aspects	.141	.106	-.008	.047	.080	.325	1.000

Table A10.84 Postgraduate importance of knowledge – Summary item statistics Cohort 1

Summary Item Statistics

Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Pre	.707	.416	.843	.427	2.026	.011	7
Post	.418	.155	.712	.558	4.600	.017	7

Table A10.85 Postgraduate importance of knowledge – Summary item statistics Cohort 2

Summary Item Statistics

Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Pre	.546	.342	.738	.396	2.159	.010	7
Post	.142	-.010	.325	.335	-31.933	.011	7

Table A10.86 Postgraduate importance of knowledge – Item-total statistics Cohort 1

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	23.76	35.579	.769	.698	.938
Sales and Marketing	23.88	34.834	.820	.739	.934
Human Resource Management	23.82	34.635	.831	.724	.933
Project planning	23.53	33.772	.843	.772	.932
Design and Production	23.82	36.816	.649	.559	.949
Quality Management	23.59	34.916	.883	.828	.929
Legal aspects	23.82	34.392	.903	.830	.927

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	25.28	8.789	.615	.548	.803
Sales and Marketing	25.41	8.894	.478	.490	.827
Human Resource Management	25.72	8.789	.571	.450	.810
Project planning	25.31	8.738	.641	.579	.800
Design and Production	25.44	8.964	.519	.310	.818
Quality Management	25.28	9.047	.604	.572	.806
Legal aspects	25.31	8.093	.652	.645	.796

Table A10.87 Postgraduate importance of knowledge – Item-total statistics Cohort 2

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	25.66	13.382	.694	.569	.878
Sales and Marketing	25.79	13.052	.776	.776	.868
Human Resource Management	25.70	12.907	.723	.604	.874
Project planning	25.30	13.946	.697	.600	.878
Design and Production	25.79	14.091	.595	.466	.889
Quality Management	25.45	13.753	.646	.511	.883
Legal aspects	25.51	13.293	.719	.685	.875

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Accounting & Finance	26.40	4.490	.237	.161	.499
Sales and Marketing	26.60	3.755	.330	.189	.456
Human Resource Management	26.52	4.132	.164	.084	.540
Project planning	25.94	4.670	.233	.092	.503
Design and Production	26.32	4.181	.259	.171	.489
Quality Management	26.24	3.696	.427	.277	.412
Legal aspects	26.30	4.296	.210	.134	.509

Table A10.88 Postgraduate importance of skills – inter-item correlation matrix Cohort 1

Inter-Item Correlation Matrix Pre									
	Give effective pres’	Quality reports	Be creative	Solve probs	Form good Q’s	Work effectively in a team	Design & produce prod/serv	Comm’ Effect-ively	Use disc’ to investi-gate
Give effective presentations	1.000	.705	.710	.695	.582	.687	.600	.715	.557
Produce quality reports	.705	1.000	.579	.669	.545	.789	.397	.694	.679
Be creative	.710	.579	1.000	.640	.591	.639	.610	.646	.518
Solve problems	.695	.669	.640	1.000	.688	.855	.476	.806	.747
Formulate good questions	.582	.545	.591	.688	1.000	.682	.652	.728	.710
Work effectively in a team	.687	.789	.639	.855	.682	1.000	.498	.845	.776
Design and produce products/services	.600	.397	.610	.476	.652	.498	1.000	.564	.512
Communicate effectively	.715	.694	.646	.806	.728	.845	.564	1.000	.657
Use discussion to investigate an issue	.557	.679	.518	.747	.710	.776	.512	.657	1.000

Inter-Item Correlation Matrix Post									
	Give effective pres’	Quality reports	Be creative	Solve probs	Form good Q’s	Work effectively in a team	Design & produce prod/serv	Comm’ Effect-ively	Use disc’ to investi-gate
Give effective presentations	1.000	.464	.436	.159	.446	.133	.338	.317	.221
Produce quality reports	.464	1.000	.293	.430	.274	.340	.178	.326	.267
Be creative	.436	.293	1.000	.298	.307	.433	.415	.118	-.058
Solve problems	.159	.430	.298	1.000	.527	.404	.185	.245	.165
Formulate good questions	.446	.274	.307	.527	1.000	.276	.355	.150	.049
Work effectively in a team	.133	.340	.433	.404	.276	1.000	.231	.367	.179
Design and produce products/services	.338	.178	.415	.185	.355	.231	1.000	.089	.057
Communicate effectively	.317	.326	.118	.245	.150	.367	.089	1.000	.385
Use discussion to investigate an issue	.221	.267	-.058	.165	.049	.179	.057	.385	1.000

Table A10.89 Postgraduate importance of skills – inter-item correlation matrix Cohort 2

Inter-Item Correlation Matrix Pre	Give effective pres'	Quality reports	Be creative	Solve probs	Form good Q's	Work effectively in a team	Design & produce prod/serv	Comm' Effect-ively	Use disc' to investi-gate
Give effective presentations	1.000	.758	.467	.690	.699	.660	.359	.726	.687
Produce quality reports	.758	1.000	.569	.604	.677	.648	.553	.675	.699
Be creative	.467	.569	1.000	.686	.459	.566	.478	.547	.440
Solve problems	.690	.604	.686	1.000	.587	.763	.250	.815	.518
Formulate good questions	.699	.677	.459	.587	1.000	.677	.324	.683	.728
Work effectively in a team	.660	.648	.566	.763	.677	1.000	.348	.797	.659
Design and produce products/services	.359	.553	.478	.250	.324	.348	1.000	.220	.410
Communicate effectively	.726	.675	.547	.815	.683	.797	.220	1.000	.670
Use discussion to investigate an issue	.687	.699	.440	.518	.728	.659	.410	.670	1.000

Inter-Item Correlation Matrix Post	Give effective pres'	Quality reports	Be creative	Solve probs	Form good Q's	Work effectively in a team	Design & produce prod/serv	Comm' Effect-ively	Use disc' to investi-gate
Give effective presentations	1.000	.636	.098	.305	.415	.205	.076	.243	.228
Produce quality reports	.636	1.000	.213	.364	.482	.368	.253	.064	-.095
Be creative	.098	.213	1.000	.160	.360	.299	.524	-.010	.194
Solve problems	.305	.364	.160	1.000	.376	.276	.121	.297	.126
Formulate good questions	.415	.482	.360	.376	1.000	.234	.495	.162	.148
Work effectively in a team	.205	.368	.299	.276	.234	1.000	.263	.091	.193
Design and produce products/services	.076	.253	.524	.121	.495	.263	1.000	.160	.245
Communicate effectively	.243	.064	-.010	.297	.162	.091	.160	1.000	.309
Use discussion to investigate an issue	.228	-.095	.194	.126	.148	.193	.245	.309	1.000

Table A10.90 Postgraduate importance of skills – Summary item statistics Cohort 1 and 2

Summary Item Statistics							
Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.651	.397	.855	.458	2.152	.011	9
Cohort 1 Post	.272	-.058	.527	.585	-9.024	.018	9
Cohort 2 Pre	.586	.220	.815	.595	3.707	.024	9
Cohort 2 Post	.247	-.095	.636	.731	-6.694	.023	9

Table A10.91 Postgraduate importance of skills – Item-total statistics Cohort 1

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	31.50	52.864	.788	.707	.937
Produce quality reports	31.65	52.599	.761	.711	.939
Be creative	31.59	54.916	.734	.601	.940
Solve problems	31.21	50.411	.848	.800	.934
Formulate good questions	31.74	54.201	.773	.686	.938
Work effectively in a team	31.44	49.830	.883	.859	.932
Design and produce products/services	31.74	56.504	.626	.572	.946
Communicate effectively	31.35	50.720	.861	.795	.933
Use discussion to investigate an issue	31.56	54.133	.776	.717	.938

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	33.56	10.448	.548	.536	.734
Produce quality reports	33.44	9.802	.534	.397	.732
Be creative	33.66	9.588	.462	.448	.748
Solve problems	33.25	10.452	.515	.468	.737
Formulate good questions	33.59	10.120	.493	.471	.739
Work effectively in a team	33.47	10.580	.505	.398	.739
Design and produce products/services	33.59	10.894	.392	.245	.754
Communicate effectively	33.19	10.867	.397	.310	.754
Use discussion to investigate an issue	33.50	11.484	.235	.231	.775

Table A10.92 Postgraduate importance of skills – Item-total statistics Cohort 2

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	34.72	24.822	.795	.717	.911
Produce quality reports	34.68	24.530	.825	.729	.909
Be creative	34.60	25.590	.650	.593	.920
Solve problems	34.42	25.171	.763	.798	.913
Formulate good questions	34.79	24.283	.759	.645	.913
Work effectively in a team	34.45	24.445	.805	.724	.910
Design and produce products/services	34.92	26.379	.445	.454	.935
Communicate effectively	34.42	24.901	.805	.798	.911
Use discussion to investigate an issue	34.85	23.938	.757	.665	.913

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Give effective presentations	35.32	8.181	.464	.562	.720
Produce quality reports	35.24	7.900	.497	.621	.713
Be creative	35.30	8.092	.418	.334	.727
Solve problems	34.96	8.733	.424	.280	.728
Formulate good questions	35.42	7.514	.601	.457	.694
Work effectively in a team	35.06	8.180	.415	.248	.727
Design and produce products/services	35.46	7.641	.480	.466	.716
Communicate effectively	35.04	9.100	.259	.219	.748
Use discussion to investigate an issue	35.48	8.785	.274	.327	.749

Table A10.93 Postgraduate importance of self-esteem – inter-item correlation matrix Cohort 1

Inter-Item Correlation Matrix Pre

	Prob Solve	Get Reso -urce	Aims Goal	Deal event	Resour-ce fulness	Rely on self	Effort	Stick Plan	Calm under stress	Gen soln's	Cope uncer-tainty	Accept Chall-enges	Think around prob	Make sense judge	Stick Plan 2
Problem solving	1.000	.063	.290	.134	.408	.261	.231	-.059	.270	.144	.280	.285	.209	.234	.046
Getting resources	.063	1.000	.093	-.165	.132	.127	.256	.059	.387	.306	.190	.354	-.169	.085	.263
Achieving aims/goals	.290	.093	1.000	.381	.244	.349	.421	.260	.366	-.139	.089	.441	.124	.366	.342
Deal with unexpected events	.134	-.165	.381	1.000	.282	.074	.029	.098	.381	-.139	.210	.003	.117	.313	.154
Resourcefulness	.408	.132	.244	.282	1.000	.183	.284	.355	.177	.367	.390	.227	.385	.198	.252
Relying on oneself	.261	.127	.349	.074	.183	1.000	.164	-.035	.284	.351	.118	.221	.528	.016	.093
Investing the appropriate effort	.231	.256	.421	.029	.284	.164	1.000	.006	.285	.004	.070	.376	-.237	.400	.087
Sticking to my plans	-.059	.059	.260	.098	.355	-.035	.006	1.000	-.027	.019	.381	.326	.220	-.081	.640
Being calm under stress	.270	.387	.366	.381	.177	.284	.285	-.027	1.000	.272	.036	.264	.097	.309	.219
Generating solutions to problems	.144	.306	-.139	-.139	.367	.351	.004	.019	.272	1.000	-.034	.050	.194	-.048	.084
Coping with uncertainty	.280	.190	.089	.210	.390	.118	.070	.381	.036	-.034	1.000	.416	.151	.007	.289
Acceptance of challenges	.285	.354	.441	.003	.227	.221	.376	.326	.264	.050	.416	1.000	.232	.279	.353
Thinking around a problem	.209	-.169	.124	.117	.385	.528	-.237	.220	.097	.194	.151	.232	1.000	-.028	.085
Making sensible judgments	.234	.085	.366	.313	.198	.016	.400	-.081	.309	-.048	.007	.279	-.028	1.000	-.026
Sticking to my plans 2	.046	.263	.342	.154	.252	.093	.087	.640	.219	.084	.289	.353	.085	-.026	1.000

Inter-Item Correlation Matrix Post

	Prob Solve	Get Reso -urce	Aims Goal s	Deal event	Resour-ce fulness	Rely on self	Effort	Stick Plan	Calm under stress	Gen soln's	Cope uncer-tainty	Accept Chall-enges	Think around prob	Make sense judge	Stick Plan 2
Problem solving	1.000	.095	.193	.462	.096	.037	.336	.032	.420	.257	.480	.112	.175	.584	.299
Getting resources	.095	1.000	-.027	.413	.150	.467	.217	.298	.158	.249	.490	.148	.196	.261	.233
Achieving aims/goals	.193	-.027	1.000	.242	-.079	.201	.253	-.049	-.007	.256	.281	-.080	.413	.272	.365
Deal with unexpected events	.462	.413	.242	1.000	.265	.300	.337	-.022	.478	.515	.618	-.258	.117	.631	.000
Resourcefulness	.096	.150	-.079	.265	1.000	.136	.159	.118	.361	.362	.170	-.304	.149	.289	-.065
Relying on oneself	.037	.467	.201	.300	.136	1.000	.335	.577	.321	.359	.339	.172	.215	.236	.422
Investing the appropriate effort	.336	.217	.253	.337	.159	.335	1.000	.346	.364	.116	.213	.079	.380	.413	.185
Sticking to my plans	.032	.298	-.049	-.022	.118	.577	.346	1.000	.065	.106	-.128	.364	.345	.153	.411
Being calm under stress	.420	.158	-.007	.478	.361	.321	.364	.065	1.000	.363	.438	-.125	.268	.574	.187
Generating solutions to problems	.257	.249	.256	.515	.362	.359	.116	.106	.363	1.000	.167	-.169	.191	.251	.056
Coping with uncertainty	.480	.490	.281	.618	.170	.339	.213	-.128	.438	.167	1.000	-.068	.162	.516	.330
Acceptance of challenges	.112	.148	-.080	-.258	-.304	.172	.079	.364	-.125	-.169	-.068	1.000	.253	.066	.470
Thinking around a problem	.175	.196	.413	.117	.149	.215	.380	.345	.268	.191	.162	.253	1.000	.452	.347
Making sensible judgments	.584	.261	.272	.631	.289	.236	.413	.153	.574	.251	.516	.066	.452	1.000	.280
Sticking to my plans 2	.299	.233	.365	.000	-.065	.422	.185	.411	.187	.056	.330	.470	.347	.280	1.000

Table A10.94 Postgraduate importance of self-esteem – inter-item correlation matrix Cohort 2

Inter-Item Correlation Matrix Pre

	Prob Solve	Get Reso-urce	Aims Goal	Deal event	Resour-ce fulness	Rely on self	Effort	Stick Plan	Calm under stress	Gen soln's	Cope uncer-tainty	Accept Chall-enges	Think around prob	Make sense judge	Stick Plan 2
Problem solving	1.000	.269	.437	.544	.464	.237	.568	.093	.313	.475	.377	.204	.604	.508	.270
Getting resources	.269	1.000	.387	.352	.251	.392	.501	.325	.192	.477	.449	.335	.372	.412	.246
Achieving aims/goals	.437	.387	1.000	.436	.301	.384	.373	.424	.246	.293	.288	.323	.419	.328	.235
Deal with unexpected events	.544	.352	.436	1.000	.641	.230	.340	.140	.440	.558	.358	.351	.419	.328	.186
Resourcefulness	.464	.251	.301	.641	1.000	.109	.266	.037	.449	.448	.391	.199	.216	.430	.322
Relying on oneself	.237	.392	.384	.230	.109	1.000	.409	.454	.127	.310	.319	.178	.141	.159	.259
Investing the appropriate effort	.568	.501	.373	.340	.266	.409	1.000	.217	.208	.361	.343	.250	.473	.513	.224
Sticking to my plans	.093	.325	.424	.140	.037	.454	.217	1.000	.059	.212	.292	.245	.159	.021	.230
Being calm under stress	.313	.192	.246	.440	.449	.127	.208	.059	1.000	.314	.352	.375	.342	.310	.100
Generating solutions to problems	.475	.477	.293	.558	.448	.310	.361	.212	.314	1.000	.490	.398	.463	.477	.254
Coping with uncertainty	.377	.449	.288	.358	.391	.319	.343	.292	.352	.490	1.000	.290	.474	.443	.334
Acceptance of challenges	.204	.335	.323	.351	.199	.178	.250	.245	.375	.398	.290	1.000	.408	.337	.108
Thinking around a problem	.604	.372	.419	.419	.216	.141	.473	.159	.342	.463	.474	.408	1.000	.346	.156
Making sensible judgments	.508	.412	.328	.328	.430	.159	.513	.021	.310	.477	.443	.337	.346	1.000	.362
Sticking to my plans 2	.270	.246	.235	.186	.322	.259	.224	.230	.100	.254	.334	.108	.156	.362	1.000

Inter-Item Correlation Matrix Post

	Prob Solve	Get Reso-urce	Aims Goal s	Deal event	Resour-ce fulness	Rely on self	Effort	Stick Plan	Calm under stress	Gen soln's	Cope uncer-tainty	Accept Chall-enges	Think around prob	Make sense judge	Stick Plan 2
Problem solving	1.000	.151	-.241	.182	.190	-.132	.068	-.250	.280	.143	-.139	.059	-.070	.110	-.166
Getting resources	.151	1.000	.123	.243	.211	-.039	.092	.236	.197	.207	.097	.130	.307	.385	.325
Achieving aims/goals	-.241	.123	1.000	.284	.314	.056	.440	.198	.246	.330	.274	.005	.335	.041	.050
Deal with unexpected events	.182	.243	.284	1.000	.524	-.081	.196	.218	.120	.510	.382	.270	.157	.080	-.016
Resourcefulness	.190	.211	.314	.524	1.000	.029	.297	.168	.314	.335	.331	.260	.178	-.052	-.108
Relying on oneself	-.132	-.039	.056	-.081	.029	1.000	.141	.328	.052	-.175	-.032	-.020	.120	.068	.115
Investing the appropriate effort	.068	.092	.440	.196	.297	.141	1.000	.092	.168	.544	.262	.156	.482	.344	.118
Sticking to my plans	-.250	.236	.198	.218	.168	.328	.092	1.000	.221	.077	.234	.151	.045	.050	.308
Being calm under stress	.280	.197	.246	.120	.314	.052	.168	.221	1.000	.073	.100	.117	.012	-.003	.134
Generating solutions to problems	.143	.207	.330	.510	.335	-.175	.544	.077	.073	1.000	.282	.138	.286	.208	.072
Coping with uncertainty	-.139	.097	.274	.382	.331	-.032	.262	.234	.100	.282	1.000	.247	.442	-.139	.373
Acceptance of challenges	.059	.130	.005	.270	.260	-.020	.068	-.250	.280	.143	-.139	1.000	.212	.121	.143
Thinking around a problem	-.070	.307	.335	.157	.178	.120	.092	.236	.197	.207	.097	.130	1.000	.300	.510
Making sensible judgments	.110	.385	.041	.080	-.052	.068	.440	.198	.246	.330	.274	.005	.300	1.000	.317
Sticking to my plans 2	-.166	.325	.050	-.016	-.108	.115	.196	.218	.120	.510	.382	.270	.510	.317	1.000

Table A10.95 Postgraduate importance of self-esteem – Summary item statistics Cohorts 1 and 2

Summary Item Statistics							
Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.188	-.237	.640	.877	-2.705	.027	15
Cohort 1 Post	.235	-.304	.631	.935	-2.080	.036	15
Cohort 2 Pre	.326	.021	.641	.620	31.162	.016	15
Cohort 2 Post	.164	-.250	.544	.794	-2.178	.028	15

Table A10.96 Postgraduate importance of self-esteem – Item-total statistics Cohort 1

Item-Total Statistics Pre

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	48.79	29.259	.396	.383	.760
Getting resources	48.94	30.239	.289	.494	.768
Achieving aims/goals	49.06	27.875	.544	.634	.747
Deal with unexpected events	49.15	29.887	.283	.547	.769
Resourcefulness	49.03	28.332	.563	.713	.748
Relying on oneself	49.53	28.317	.396	.671	.760
Investing the appropriate effort	48.74	29.837	.333	.622	.765
Sticking to my plans	49.71	29.184	.304	.615	.768
Being calm under stress	49.12	26.471	.478	.548	.751
Generating solutions to problems	48.88	30.531	.209	.573	.774
Coping with uncertainty	48.88	29.561	.364	.537	.762
Acceptance of challenges	49.21	27.865	.560	.611	.746
Thinking around a problem	48.94	29.572	.281	.723	.770
Making sensible judgments	48.91	29.780	.279	.362	.769
Sticking to my plans 2	48.94	27.996	.421	.523	.757

Item-Total Statistics Post

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	54.88	29.855	.473	.606	.809
Getting resources	55.00	29.097	.451	.560	.809
Achieving aims/goals	55.03	30.418	.285	.674	.819
Deal with unexpected events	54.94	27.931	.530	.767	.803
Resourcefulness	54.91	30.862	.243	.395	.821
Relying on oneself	55.38	27.726	.576	.709	.800
Investing the appropriate effort	54.56	28.964	.503	.455	.806
Sticking to my plans	55.38	28.823	.353	.716	.818
Being calm under stress	54.94	27.609	.506	.648	.805
Generating solutions to problems	54.97	29.257	.408	.621	.812
Coping with uncertainty	54.78	29.080	.529	.772	.805
Acceptance of challenges	55.19	31.706	.098	.552	.831
Thinking around a problem	54.94	28.770	.493	.573	.806
Making sensible judgments	54.91	27.378	.669	.712	.794
Sticking to my plans 2	54.91	28.281	.468	.645	.808

Table A10.97 Postgraduate importance of self-esteem – Item-total statistics Cohort 2

Item-Total Statistics Pre

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	49.49	44.293	.622	.637	.859
Getting resources	49.68	44.607	.586	.466	.861
Achieving aims/goals	49.62	43.893	.575	.462	.861
Deal with unexpected events	49.62	43.509	.615	.606	.859
Resourcefulness	49.74	44.890	.523	.572	.863
Relying on oneself	50.45	44.060	.434	.418	.869
Investing the appropriate effort	49.26	44.083	.589	.545	.860
Sticking to my plans	50.57	45.712	.344	.389	.873
Being calm under stress	49.42	45.440	.435	.343	.867
Generating solutions to problems	49.68	43.568	.648	.534	.858
Coping with uncertainty	49.60	44.282	.611	.476	.860
Acceptance of challenges	49.96	44.229	.458	.362	.867
Thinking around a problem	49.43	44.943	.574	.598	.862
Making sensible judgments	49.57	43.597	.575	.554	.861
Sticking to my plans 2	49.87	44.501	.379	.257	.873

Item-Total Statistics Post

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Problem solving	49.20	29.714	.009	.419	.748
Getting resources	49.92	34.483	.397	.371	.560
Achieving aims/goals	49.78	34.991	.234	.461	.575
Deal with unexpected events	49.92	32.728	.486	.534	.540
Resourcefulness	49.80	33.429	.484	.460	.547
Relying on oneself	50.70	36.827	.007	.262	.610
Investing the appropriate effort	49.34	32.719	.481	.597	.541
Sticking to my plans	51.12	35.291	.204	.415	.579
Being calm under stress	49.72	34.287	.374	.363	.560
Generating solutions to problems	49.68	33.079	.453	.524	.546
Coping with uncertainty	49.94	33.731	.316	.518	.562
Acceptance of challenges	50.20	33.347	.281	.182	.565
Thinking around a problem	49.66	34.556	.436	.584	.559
Making sensible judgments	49.78	35.277	.271	.447	.573
Sticking to my plans 2	50.24	35.043	.220	.565	.577

Table A10.98 Postgraduate importance of self-efficacy – inter-item correlation matrix Cohort 1

Inter-Item Correlation Matrix Pre

	Finish on time	Conc on Eng subs	Take notes	Use search engine	Plan & Org work	Remem -ber lectures	Remem -ber practice	Moti-vate self	Take part in disc’	Esti-mate	Design & Cons	Lead tech team	Doc tech proc’	Write project plan
Finish report/assign on time	1.000	.415	.050	-.091	.317	.137	.216	.062	.235	.004	.101	.120	.039	.298
Conc on tech eng subjects	.415	1.000	.416	.321	.339	.285	.208	.203	.158	.175	.252	.484	.218	.549
Take usable class notes	.050	.416	1.000	.257	.311	.304	.328	.113	-.031	.101	.167	.105	.184	.363
Use search engines	-.091	.321	.257	1.000	.403	.237	.167	.188	.262	.281	.120	.462	.535	.321
Plan/organise your workload	.317	.339	.311	.403	1.000	.326	.256	.376	.209	.418	.453	.408	.374	.288
Remember 'Eng Des' lecture	.137	.285	.304	.237	.326	1.000	.680	.312	.374	.146	.229	.239	.471	.433
Remember 'Eng Des'' prac	.216	.208	.328	.167	.256	.680	1.000	.141	.062	.031	.123	.131	.483	.386
Motivate yourself to study	.062	.203	.113	.188	.376	.312	.141	1.000	.368	.363	.208	.343	.354	.475
Take part in discussions	.235	.158	-.031	.262	.209	.374	.062	.368	1.000	.481	.215	-.005	.212	.216
Review/estimate durations	.004	.175	.101	.281	.418	.146	.031	.363	.481	1.000	.429	.070	.293	.312
Design/construct experiment maintaining spec’ conditions	.101	.252	.167	.120	.453	.229	.123	.208	.215	.429	1.000	.486	.495	.252
Lead a tech team to success	.120	.484	.105	.462	.408	.239	.131	.343	-.005	.070	.486	1.000	.541	.391
Document tech procedures	.039	.218	.184	.535	.374	.471	.483	.354	.212	.293	.495	.541	1.000	.442
Write an eng’ project plan	.298	.549	.363	.321	.288	.433	.386	.475	.216	.312	.252	.391	.442	1.000

Inter-Item Correlation Matrix Post

	Finish on time	Conc on Eng subs	Take notes	Use search engine	Plan & Org work	Remem -ber lectures	Remem -ber practice	Moti-vate self	Take part in disc’	Esti-mate	Design & Cons	Lead tech team	Doc tech proc’	Write project plan
Finish report/assign on time	1.000	.438	.371	.484	-.294	.316	.104	.354	.099	.265	.077	.431	.400	.604
Conc on tech eng subjects	.438	1.000	.146	.402	-.109	.145	.102	.223	-.165	.249	.076	.295	.393	.133
Take usable class notes	.371	.146	1.000	.424	.251	.294	.207	.359	.499	.391	.536	.444	.419	.336
Use search engines	.484	.402	.424	1.000	.118	.470	.294	.387	.281	.370	.113	.330	.584	.561
Plan/organise your workload	-.294	-.109	.251	.118	1.000	.115	.330	.211	.369	.247	.171	.088	.162	-.251
Remember 'Eng Des' lecture	.316	.145	.294	.470	.115	1.000	.270	.298	.435	.322	.415	.378	.486	.281
Remember 'Eng Des'' prac	.104	.102	.207	.294	.330	.270	1.000	.170	.098	.447	.292	.072	.298	.234
Motivate yourself to study	.354	.223	.359	.387	.211	.298	.170	1.000	.184	.414	.542	.491	.517	.221
Take part in discussions	.099	-.165	.499	.281	.369	.435	.098	.184	1.000	.210	.320	.512	.237	.224
Review/estimate durations	.265	.249	.391	.370	.247	.322	.447	.414	.210	1.000	.464	.272	.437	.315
Design/construct experiment maintaining spec’ conditions	.077	.076	.536	.113	.171	.415	.292	.542	.320	.464	1.000	.341	.350	.120
Lead a tech team to success	.431	.295	.444	.330	.088	.378	.072	.491	.512	.272	.341	1.000	.147	.454
Document tech procedures	.400	.393	.419	.584	.162	.486	.298	.517	.237	.437	.350	.147	1.000	.274
Write an eng’ project plan	.604	.133	.336	.561	-.251	.281	.234	.221	.224	.315	.120	.454	.274	1.000

Table A10.99 Postgraduate importance of self-efficacy – inter-item correlation matrix Cohort 2

Inter-Item Correlation Matrix Pre

	Finish on time	Conc on Eng subs	Take notes	Use search engine	Plan & Org work	Remem -ber lectures	Remem -ber practice	Moti- vate self	Take part in disc’	Esti- mate	Design & Cons	Lead tech team	Doc tech proc’	Write project plan
Finish report/assign on time	1.000	.328	.261	.185	.366	.445	.328	.301	.303	.273	.325	.282	.240	.223
Conc on tech eng subjects	.328	1.000	.324	.379	.187	.275	.282	.276	.219	.020	.167	.062	.049	.055
Take usable class notes	.261	.324	1.000	.231	.365	.344	.381	.201	.195	.045	.106	.166	.020	.055
Use search engines	.185	.379	.231	1.000	.022	-.083	-.030	-.002	-.001	-.041	-.036	-.317	-.208	.063
Plan/organise your workload	.366	.187	.365	.022	1.000	.517	.424	.393	.409	.451	.391	.390	.366	.403
Remember 'Eng Des' lecture	.445	.275	.344	-.083	.517	1.000	.801	.505	.448	.380	.398	.306	.393	.438
Remember 'Eng Des'' prac	.328	.282	.381	-.030	.424	.801	1.000	.553	.492	.426	.546	.378	.445	.429
Motivate yourself to study	.301	.276	.201	-.002	.393	.505	.553	1.000	.516	.516	.458	.305	.331	.369
Take part in discussions	.303	.219	.195	-.001	.409	.448	.492	.516	1.000	.470	.626	.430	.270	.330
Review/estimate durations	.273	.020	.045	-.041	.451	.380	.426	.516	.470	1.000	.519	.443	.442	.391
Design/construct experiment maintaining spec’ conditions	.325	.167	.106	-.036	.391	.398	.546	.458	.626	.519	1.000	.392	.503	.402
Lead a tech team to success	.282	.062	.166	-.317	.390	.306	.378	.305	.430	.443	.392	1.000	.286	.321
Document tech procedures	.240	.049	.020	-.208	.366	.393	.445	.331	.270	.442	.503	.286	1.000	.553
Write an eng’ project plan	.223	.055	.055	.063	.403	.438	.429	.369	.330	.391	.402	.321	.553	1.000

Inter-Item Correlation Matrix Post

	Finish on time	Conc on Eng subs	Take notes	Use search engine	Plan & Org work	Remem -ber lectures	Remem -ber practice	Moti- vate self	Take part in disc’	Esti- mate	Design & Cons	Lead tech team	Doc tech proc’	Write project plan
Finish report/assign on time	1.000	.259	.199	.080	.050	.039	.098	.061	.105	.425	.024	.147	.133	.058
Conc on tech eng subjects	.259	1.000	.505	.254	.368	.381	.232	.430	.187	.267	.365	.234	.020	.164
Take usable class notes	.199	.505	1.000	.468	.198	.366	.388	.433	.190	.314	.333	.273	.112	.317
Use search engines	.080	.254	.468	1.000	.324	.168	.233	.367	.174	.174	.065	.169	.246	.176
Plan/organise your workload	.050	.368	.198	.324	1.000	.418	.376	.333	.539	.350	.536	.542	.341	.410
Remember 'Eng Des' lecture	.039	.381	.366	.168	.418	1.000	.649	.265	.111	.358	.448	.566	-.055	.442
Remember 'Eng Des'' prac	.098	.232	.388	.233	.376	.649	1.000	.225	.445	.387	.446	.620	.201	.373
Motivate yourself to study	.061	.430	.433	.367	.333	.265	.225	1.000	.261	.307	.460	.252	.321	.329
Take part in discussions	.105	.187	.190	.174	.539	.111	.445	.261	1.000	.320	.491	.516	.460	.401
Review/estimate durations	.425	.267	.314	.174	.350	.358	.387	.307	.320	1.000	.414	.505	.187	.426
Design/construct experiment maintaining spec’ conditions	.024	.365	.333	.065	.536	.448	.446	.460	.491	.414	1.000	.557	.321	.366
Lead a tech team to success	.147	.234	.273	.169	.542	.566	.620	.252	.516	.505	.557	1.000	.415	.706
Document tech procedures	.133	.020	.112	.246	.341	-.055	.201	.321	.460	.187	.321	.415	1.000	.219
Write an eng’ project plan	.058	.164	.317	.176	.410	.442	.373	.329	.401	.426	.366	.706	.219	1.000

Table A10.100 Postgraduate importance of self-efficacy – Summary item statistics Cohorts 1 and 2

Summary Item Statistics							
Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.275	-.091	.680	.771	-7.477	.023	14
Cohort 1 Post	.288	-.294	.604	.898	-2.058	.029	14
Cohort 2 Pre	.299	-.317	.801	1.118	-2.529	.037	14
Cohort 2 Post	.309	-.055	.706	.762	-12.768	.025	14

Table A10.101 Postgraduate importance of self-efficacy – Item-total statistics Cohort 1

Item-Total Statistics Pre	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish report/assign on time	48.24	37.761	.249	.544	.841
Conc on tech eng subjects	48.62	35.698	.543	.586	.825
Take usable class notes	49.06	36.421	.354	.411	.836
Use search engines	48.65	35.932	.464	.678	.829
Plan/organise your workload	48.59	33.765	.607	.612	.819
Remember 'Eng Des' lecture	49.06	33.815	.578	.656	.821
Remember 'Eng Des'' prac	49.09	34.568	.437	.629	.832
Motivate yourself to study	48.50	36.561	.462	.525	.829
Take part in discussions	48.32	36.892	.343	.617	.836
Review/estimate durations	48.62	37.092	.400	.555	.833
Design/construct experiment maintaining spec' conditions	48.97	34.817	.473	.633	.828
Lead a tech team to success	49.15	34.129	.504	.701	.826
Document tech procedures	49.03	34.029	.650	.683	.817
Write an eng' project plan	48.62	34.971	.638	.588	.819

Item-Total Statistics Post	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish report/assign on time	52.38	29.339	.495	.659	.845
Conc on tech eng subjects	52.50	31.355	.305	.623	.855
Take usable class notes	52.63	27.984	.627	.640	.837
Use search engines	52.47	27.676	.644	.703	.836
Plan/organise your workload	52.38	32.306	.169	.563	.861
Remember 'Eng Des' lecture	52.66	28.362	.562	.568	.841
Remember 'Eng Des'' prac	52.59	31.088	.371	.384	.852
Motivate yourself to study	52.47	28.773	.580	.719	.840
Take part in discussions	52.44	29.931	.442	.645	.848
Review/estimate durations	52.50	29.290	.576	.438	.841
Design/construct experiment maintaining spec' conditions	52.59	29.088	.498	.702	.845
Lead a tech team to success	52.56	28.641	.575	.750	.841
Document tech procedures	52.31	28.867	.627	.675	.838
Write an eng' project plan	52.44	29.157	.474	.690	.847

Table A10.102 Postgraduate importance of self-efficacy – Item-total statistics Cohort 2

Item-Total Statistics Pre					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish report/assign on time	52.23	35.755	.502	.370	.841
Conc on tech eng subjects	52.53	35.908	.322	.349	.852
Take usable class notes	52.30	36.676	.342	.354	.849
Use search engines	52.51	39.255	.009	.491	.869
Plan/organise your workload	52.53	34.523	.615	.463	.835
Remember 'Eng Des' lecture	52.92	33.071	.676	.754	.829
Remember 'Eng Des'' prac	52.91	32.933	.725	.759	.827
Motivate yourself to study	52.34	35.306	.623	.470	.836
Take part in discussions	52.57	33.404	.620	.521	.833
Review/estimate durations	52.64	34.196	.565	.504	.837
Design/construct experiment maintaining spec' conditions	52.77	33.755	.634	.581	.832
Lead a tech team to success	53.02	34.019	.439	.484	.846
Document tech procedures	52.75	35.304	.479	.515	.842
Write an eng' project plan	52.81	34.194	.524	.484	.839

Item-Total Statistics Post					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Finish report/assign on time	51.44	42.890	.207	.309	.870
Conc on tech eng subjects	51.75	40.106	.462	.472	.859
Take usable class notes	51.90	39.244	.518	.519	.856
Use search engines	51.54	41.232	.359	.407	.864
Plan/organise your workload	51.71	38.977	.625	.563	.851
Remember 'Eng Des' lecture	52.10	38.776	.535	.690	.856
Remember 'Eng Des'' prac	52.23	38.010	.612	.644	.851
Motivate yourself to study	51.73	39.138	.516	.472	.857
Take part in discussions	51.79	38.551	.540	.577	.855
Review/estimate durations	51.85	38.383	.565	.456	.854
Design/construct experiment maintaining spec' conditions	52.19	37.219	.634	.589	.849
Lead a tech team to success	52.04	36.934	.725	.770	.844
Document tech procedures	52.17	40.652	.368	.469	.864
Write an eng' project plan	51.67	39.504	.572	.613	.854

Table A10.103 Postgraduate learning style preference – inter-item correlation matrix Cohort 1

Inter-Item Correlation Matrix Pre

	Operate New Eqpt	Need Direct-ions	Cook	Teach	Tend to say	Free time	Choose holiday	Shop	Conc-entrate	New skill
When I operate new equipment I …	1.000	.228	.199	.353	-.018	.418	.075	-.254	.387	.281
If I am going somewhere new and need directions I usually	.228	1.000	.364	.144	-.038	.087	-.093	-.196	-.061	.339
If I am cooking a new dish I generally	.199	.364	1.000	.305	.114	.149	.361	-.222	.144	.323
If I am teaching someone something new I tend to	.353	.144	.305	1.000	.371	.164	.269	-.194	.255	.295
In general conversation I would tend to say	-.018	-.038	.114	.371	1.000	-.209	-.144	.077	.349	.095
During my free time I would rather	.418	.087	.149	.164	-.209	1.000	.116	.058	.140	.342
If I were choosing a holiday I would prefer to	.075	-.093	.361	.269	-.144	.116	1.000	-.069	.096	.052
If I were out shopping for clothes I would tend to	-.254	-.196	-.222	-.194	.077	.058	-.069	1.000	-.063	-.137
When I concentrate, I most often	.387	-.061	.144	.255	.349	.140	.096	-.063	1.000	.211
When I am learning a new skill I feel most comfortable when	.281	.339	.323	.295	.095	.342	.052	-.137	.211	1.000

Inter-Item Correlation Matrix Post

	Operate New Eqpt	Need Direct-ions	Cook	Teach	Tend to say	Free time	Choose holiday	Shop	Conc-entrate	New skill
When I operate new equipment I…	1.000	.044	.268	.165	.045	.315	.169	.037	.014	.256
If I am going somewhere new and need directions I usually	.044	1.000	.056	.140	.216	.026	.345	-.220	-.076	.203
If I am cooking a new dish I generally	.268	.056	1.000	.463	.035	.039	.169	.151	.281	.323
If I am teaching someone something new I tend to	.165	.140	.463	1.000	.145	.128	.131	.212	.158	.026
In general conversation I would tend to say	.045	.216	.035	.145	1.000	-.081	-.244	.222	-.079	.099
During my free time I would rather	.315	.026	.039	.128	-.081	1.000	.305	.243	.366	.185
If I were choosing a holiday I would prefer to	.169	.345	.169	.131	-.244	.305	1.000	-.164	.197	.058
If I were out shopping for clothes I would tend to	.037	-.220	.151	.212	.222	.243	-.164	1.000	.114	.018
When I concentrate, I most often	.014	-.076	.281	.158	-.079	.366	.197	.114	1.000	.387
When I am learning a new skill I feel most comfortable when	.256	.203	.323	.026	.099	.185	.058	.018	.387	1.000

Table A10.104 Postgraduate learning style preference – inter-item correlation matrix Cohort 2

Inter-Item Correlation Matrix Pre

	Operate New Eqpt	Need Direct-ions	Cook	Teach	Tend to say	Free time	Choose holiday	Shop	Conc-entrate	New skill
When I operate new equipment I …	1.000	.063	-.204	.064	-.263	-.125	.207	-.130	-.101	.234
If I am going somewhere new and need directions I usually	.063	1.000	.169	.252	.210	.052	.209	.000	-.243	.074
If I am cooking a new dish I generally	-.204	.169	1.000	.216	-.040	.106	.022	-.188	-.131	-.102
If I am teaching someone something new I tend to	.064	.252	.216	1.000	.034	-.129	.089	-.033	.021	.187
In general conversation I would tend to say	-.263	.210	-.040	.034	1.000	.133	.010	.204	-.162	.119
During my free time I would rather	-.125	.052	.106	-.129	.133	1.000	.101	.097	-.135	-.133
If I were choosing a holiday I would prefer to	.207	.209	.022	.089	.010	.101	1.000	-.159	-.342	.182
If I were out shopping for clothes I would tend to	-.130	.000	-.188	-.033	.204	.097	-.159	1.000	.223	.043
When I concentrate, I most often	-.101	-.243	-.131	.021	-.162	-.135	-.342	.223	1.000	-.004
When I am learning a new skill I feel most comfortable when	.234	.074	-.102	.187	.119	-.133	.182	.043	-.004	1.000

Inter-Item Correlation Matrix Post

	Operate New Eqpt	Need Direct-ions	Cook	Teach	Tend to say	Free time	Choose holiday	Shop	Conc-entrate	New skill
When I operate new equipment I…	1.000	.018	.004	-.042	-.072	.042	-.145	.055	.132	-.096
If I am going somewhere new and need directions I usually	.018	1.000	.062	.121	-.136	-.190	.119	-.452	-.229	.122
If I am cooking a new dish I generally	.004	.062	1.000	-.031	.041	.034	.238	-.027	-.082	.159
If I am teaching someone something new I tend to	-.042	.121	-.031	1.000	.036	.068	.020	-.096	.019	.008
In general conversation I would tend to say	-.072	-.136	.041	.036	1.000	.083	.013	.043	-.058	-.062
During my free time I would rather	.042	-.190	.034	.068	.083	1.000	.103	.067	.071	-.102
If I were choosing a holiday I would prefer to	-.145	.119	.238	.020	.013	.103	1.000	-.270	-.079	-.175
If I were out shopping for clothes I would tend to	.055	-.452	-.027	-.096	.043	.067	-.270	1.000	.106	.082
When I concentrate, I most often	.132	-.229	-.082	.019	-.058	.071	-.079	.106	1.000	.101
When I am learning a new skill I feel most comfortable when	1.000	.018	.004	-.042	-.072	.042	-.175	.082	.101	1.000

Table A10.105 Postgraduate learning style preference – Summary item statistics Cohort 1 and 2

Summary Item Statistics							
Inter-item Correlations	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Cohort 1 Pre	.121	-.254	.418	.672	-1.649	.037	10
Cohort 1 Post	.131	-.244	.463	.708	-1.895	.024	10
Cohort 2 Pre	.016	-.342	.252	.595	-.737	.024	10
Cohort 2 Post	-.008	-.452	.238	.689	-.526	.016	10

Table A10.106 Postgraduate learning style preference – Item-total statistics Cohort

Item-Total Statistics Pre	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
When I operate new equipment I generally	18.12	10.471	.396	.417	.525
If I am going somewhere new and need directions I usually	18.41	11.825	.199	.305	.574
If I am cooking a new dish I generally	17.97	9.908	.425	.369	.511
If I am teaching someone something new I tend to	17.50	10.318	.497	.406	.503
In general conversation I would tend to say	17.76	11.822	.141	.428	.590
During my free time I would rather	17.59	11.280	.309	.342	.550
If I were choosing a holiday I would prefer to	17.76	11.701	.164	.319	.585
If I were out shopping for clothes I would tend to	17.15	13.887	-.217	.183	.668
When I concentrate, I most often	17.82	10.877	.359	.323	.537
When I am learning a new skill I feel most comfortable when	17.53	10.014	.438	.295	.509

Item-Total Statistics Post	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
When I operate new equipment I generally	18.07	10.340	.323	.260	.575
If I am going somewhere new and need directions I usually	18.10	11.403	.181	.350	.605
If I am cooking a new dish I generally	17.63	9.551	.444	.392	.542
If I am teaching someone something new I tend to	17.37	10.171	.369	.308	.564
In general conversation I would tend to say	17.77	11.909	.065	.243	.625
During my free time I would rather	17.13	10.326	.372	.373	.565
If I were choosing a holiday I would prefer to	17.33	10.437	.221	.359	.603
If I were out shopping for clothes I would tend to	16.93	11.375	.127	.261	.619
When I concentrate, I most often	17.57	10.599	.347	.368	.572
When I am learning a new skill I feel most comfortable when	17.30	9.803	.359	.348	.565

Table A10.107 Postgraduate learning style preference – Item-total statistics Cohort 2

Item-Total Statistics Pre	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
When I operate new equipment I generally	18.54	4.842	-.074	.241	.170
If I am going somewhere new and need directions I usually	18.77	4.416	.289	.187	.001
If I am cooking a new dish I generally	18.17	4.577	-.052	.195	.170
If I am teaching someone something new I tend to	17.75	4.034	.220	.162	-.025[a]
In general conversation I would tend to say	18.00	4.588	.062	.229	.086
During my free time I would rather	17.65	4.505	-.002	.107	.128
If I were choosing a holiday I would prefer to	17.87	4.080	.114	.203	.038
If I were out shopping for clothes I would tend to	17.17	4.734	-.024	.160	.137
When I concentrate, I most often	18.08	5.445	-.256	.240	.237
When I am learning a new skill I feel most comfortable when	17.31	4.100	.185	.157	-.002[a]

Item-Total Statistics Post	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
When I operate new equipment I generally	18.22	4.869	-.053	.080	.026
If I am going somewhere new and need directions I usually	18.56	5.313	-.146	.316	.043
If I am cooking a new dish I generally	17.86	3.796	.157	.116	-.182[a]
If I am teaching someone something new I tend to	17.46	4.621	.012	.034	-.023[a]
In general conversation I would tend to say	17.86	4.694	-.016	.041	-.001[a]
During my free time I would rather	17.46	4.539	.088	.072	-.074[a]
If I were choosing a holiday I would prefer to	17.64	4.807	-.063	.198	.038
If I were out shopping for clothes I would tend to	17.00	5.020	-.102	.266	.061
When I concentrate, I most often	17.72	4.736	.021	.111	-.027[a]
When I am learning a new skill I feel most comfortable when	17.34	4.474	.003	.151	-.016[a]

Appendix 11 – Precis of all post teaching interviews

UG Interview Responses (summarised) – Cohort 1 used a Didactic Teaching Approach, Cohort 2 used an Active Teaching Approach

There was a total of 4 UG interviews for cohort 1 (blue text) and 6 UG interviews for cohort 2 (black text) and the following information was gathered. Highlighted text (various colours) is useful for reporting purposes.

	Respondent					
Category	EU Female	EU Male	Chinese Female	Chinese Male	UK Male 1	UK Male 2
Importance of Knowledge **COMMS** **No Specific Changes**	Team work element poor at first due to lack of knowledge in dealing with engagement – more communications needed. I have always considered knowledge in the broadest sense to be important, my views have not changed.	Recording what you learn (new knowledge) is poor despite being advised to do so in lectures. Not really changed at all, I would single out the marketing one if asked but have always felt all of them to be important	All knowledge is important. Combine engineering and business is good. Yes, always important to have knowledge. Quality management and team working seem more important now.	Confirmed earlier thinking & helped firm up knowledge. HR important for EE work but not much for Uni. Men try to be tougher. Nothing other than what I would expect by being given new information.	None for Cohort 1 Nothing changed at all in the underlying importance of knowledge – simply re-enforced my opinion.	None for Cohort 1 No changes.

Category	EU Female	EU Male	Chinese Female	Chinese Male	UK Male 1	UK Male 2
Importance of Skills **Skills easier to assess** **Comms again** **Team working** **Easier to assess** **M = Know** **F = Skill**	Not enough up-front experience of problem solving so more guidance/info here would be good. A good module for Year 2 preparation Yes, some things have changed such as the importance of presentation and team working skills and I think it is easier to assess skills in the practical domain than subjective knowledge.	I liked this for the scope it gives on using hardware and software. Need more practice though The same except for communications at the 2nd time felt really important. Creativity is also important but mine didn't change. Knowledge is easier to assess than skills.	Females generally not as forceful as males but my skills have changed in team work, writing and in presentation. Skills easier to assess than knowledge. Depends on the context and how it is explained but report writing, asking good questions, problem solving and team working skills are more important than I thought.	Changed in odd ways some feel more and some less important. E.g. team working has made me realise we don't all need all of the skills so we can rely on others. Presentations more important. Skills are easier to assess esp. written reports where you are assessing my opinion of my own knowledge. Not changed due to teaching but taken in context there will always be changes.	None for Cohort 1 Probably no changes, but there is a focus on team working skills that is probably missed by many students with no work experience.	None for Cohort 1 Still the same but knowledge is easier to assess.
Improve **Planning** **Nothing obvious**	I think there is a need in general for more exams on the course. Especially at early stages. Only have 2 formative exams – feels not enough. The opportunity to improve is vital.	Modules seem to bring positive stress as you can plan for assessments - exams are negative stress. Not really planning just revision. Yes, everyone wants to improve.	Wasn't sure about engineering at first but this has firmed up and I like some teaching more than others. Doesn't everyone want to improve?	Teaching helped me to see knowledge as interdependent to skills I rely more on own ability now than when I started Something I learned. Better planner than I used to be. This opportunity to improve is key.	None for Cohort 1 No real opinion – isn't this obvious!	None for Cohort 1 Of course.

Category	EU Female	EU Male	Chinese Female	Chinese Male	UK Male 1	UK Male 2
Thinking **R4 views different to others** **All but one tend to more reflective thinking – key point from UK Female**	Education is about sitting and listening to the lectures. Found I had to take lots of notes though. This altered my way of thinking about things massively as you do need to understand what is being taught. This depends on the context but before I would gather info & read then do – now I would be more experimental but still relate to reading.	Style of lecture is what I am used to but needed to listen carefully. Found I was thinking more about the lesson than I used to do. Yes, I reflect more.	This has changed, I want to think more about lessons and get used to workload because we will do exams in summer and the pressure will start to build soon I think. My thinking is now more focussed and includes experiment and reflection. I think on a bigger scale, focus on what might happen rather than what has to be done.	I used to theorise a lot and I still see the benefit of this style of thinking but now I have a more hands on approach. More reflective in general.	None for Cohort 1 I think my thinking style has not really changed. I have a mature outlook anyway and it was my decision to move forward.	None for Cohort 1 Yes, I reflect more and also have improved my reading around the module content. I feel this is more practical reflection than anything else.
Learning **Nothing** **Generally more enquiring supports reflective trend**	My learning style has not changed much through the course. Before I would mainly do practical after reading to consolidate. Some visual learning as appropriate. No changes really.	Because I think more about my learning I tend to do more reading. I practice questions more now and tend to keep more notes but generally this study is helping me to improve.	Not really changed - want to study more. Learning was only kinaesthetic but has changed so much through available university resources. I now use a mix of reading, note taking and experimentation.	No real changes to my approach to learning. I have changed and now use a study plan which is something I would not have done before this course.	None for Cohort 1 Asking questions and discussing in class is good. I am beginning to move forwards but a shock was needed for me to move forward.	None for Cohort 1 I knew my learning style was different because I used my spare time more constructively but I could not put a label on it.

Category	EU Female	EU Male	Chinese Female	Chinese Male	UK Male 1	UK Male 2
Self-Esteem **Comms again + generally improved** **As above, no major reason but getting resources and sticking to plans seem key factors**	Quite confident anyway but recognise the need to work with people has affected this negatively. I have always felt comfortable with my abilities but maybe the independence of Uni life has improved my confidence. Made me feel more able to get what I need, generate solutions to problems and stick to what I had planned.	I don't really have an opinion on this. More confident in my ability to achieve my aims, get resources, stick to plans and documentation but feel these will improve more with practice. Discussion has improved but also due to friendship groups.	Feel more confident maybe because I am getting experience with things and I realise just how difficult the course is. I do not always stick to my plans but feel this may be a lack of communication. I have certainly more confidence to get resources, stay calm, generate solutions and stick to what I have planned. I do use more planning now than I used to and have an active use of time to cope with stress.	This has changed for me as I now feel more confident with hardware than software, used to be the other way around. I now see things differently and can question more effectively. More capable in problem solving, open to ideas and more willing to consider details of other's ideas. Questions in lectures, I have been inspired to improve my ability to investigate.	None for Cohort 1 A slight rise in relying on my own abilities but no big changes. May be due to maturity level but for me, procrastination is a major problem. Nothing so far has helped me to get around this.	None for Cohort 1 I think that continuous education (school-6th form-HE) leads to learner fatigue. Passion for education and the drive to learn is lower in younger people or those that have been spoon fed in the past. I feel my research skills are improving and I rely on myself more.

Category	EU Female	EU Male	Chinese Female	Chinese Male	UK Male 1	UK Male 2
Self-Efficacy **Take own responsibility and plan more** **M = more realistic** **F = take more of the responsibility for their own learning**	I recognise the need to rely more on my own abilities than I used to do. Sometimes I can do things in labs that I couldn't so there are changes in me to take responsibility for my learning but most of the other students do not.	I know that I need to take more responsibility for my own learning as lectures do not cover everything. More realistic in recognising my own shortcomings. The Eng Design project will help to raise my confidence to achieve even more. I use Google to search	A little more confident about the future - learned a lot more about the topics and now able to see where I need to be. i.e. turn Plans into reality. Really changed from a team perspective and reflects the view that we are not all the same but that I have changed.	Tend to look forward and make decisions on my study but I have changed and now recognise the need for better planning for assessments. More realistic in what I want – I am more confident in asking for help.	None for Cohort 1 No real changes here, one needs to see what it is like to fail before one gets truly motivated.	None for Cohort 1 More realistic in my aspirations – the course is a lot slower than I thought it would be but the reading helps in my drive for learning about intrapreneurship within companies.

Category	EU Female	EU Male	Chinese Female	Chinese Male	UK Male 1	UK Male 2
General thoughts on teaching style Some people do reflect more now but if there is a balanced response to thinking styles, moving that balance to a more polarised one by using a different teaching style might not be desirable or beneficial. **General feel that active teaching is more beneficial in the right context**	I prefer some of the other lectures where they have interactive Q&A to do or gapped handouts. I like being involved and active teaching works for all students. Many will switch off if pure lecture based and use social media group chat instead. General fear of trick questions where correct answer is unlikely. Interaction is good, especially where there is no penalty for answering.	Straight lectures are OK as I am used to them but chance to do things in lectures as well is better. Yes, active is good, liked discussions but more info up front on the project, check pre-Uni syllabus for commonality and do some elements of the project in-class beforehand.	Like the idea of flipped learning as I like filling gapped handouts and quiz style lessons. Keeps attendance high as don't know what is coming. This is good if doing quiz in class as more people answer so don't feel foolish if give wrong answer – just one of the few that did. (**NOTE: this student is Chinese but did 'A' levels in UK**) Active works in the right context e.g. it would not be always correct in say a Maths module.	Lectures are beneficial overall but would like more of the style where we all have to respond rather than one or two people offering an opinion. Better to use active teaching as it improves a student's confidence level.	None for Cohort 1 I eventually got used to being asked to discuss things and became quicker at responding. This would help in team building if done as a class activity.	None for Cohort 1 No real thoughts but do like being involved in lessons.

PG Interview Responses (summarised) – Cohort 1 used a Didactic Teaching Approach, Cohort 2 used an Active Teaching Approach

There was a total of 4 PG interviews for cohort 1 (blue text) and 6 PG interviews for cohort 2 (black text) and the following information was gathered. Highlighted text (various colours) is useful for reporting purposes.

	Respondent					
Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
Importance of Knowledge **Importance was raised in both cohorts – language is indicted**	Need this in order to improve your ability or skill level More important than at first, especially Sales and Marketing which was a surprise.	Need for knowledge is more than I thought it would be but mainly used to develop skills More enhanced but not especially.	Some knowledge assessment is easy but not all. Give more creative ideas. Yes, now feel to be more important.	Knowledge theory is very important e.g. HRM in teams. No real changes but overall, knowledge seems more important in these areas.	None for Cohort 1 More enhanced but not much. Probably due to level of English more.	None for Cohort 1 More enhanced in general but not especially. Could be due to language issues at first and now better understanding of this question helps.

Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
Importance of Skills **Mix views on S vs K being easier to assess** **F = skills** **M = non committed**	It is easier to assess skills improvement but depends on knowledge. Team working through leadership skills is improved but not necessarily due to teaching approach Not really changed but easier to assess skills.	As before, depends on your knowledge. It is easier now for me to assess what knowledge I need to develop new skills. Teachers explaining things has helped. Maybe still the same but all should exist to a certain extent. Too subjective to say.	Effective presentations are necessary but not very important. Skills generally need developing – I agree. Yes, knowledge of skills seems more important now and skills are easier to assess.	Practice makes perfect esp in team working. Searching for info is needed as a skill. Need to be independent in your learning. Yes, especially with communications. Experiential learning is more valuable.	Yes, I have changed, improved, especially in presentations. Practice is needed.	Maybe still the same but knowledge is easier to assess. Creativity is key but the environment is crucial – engineers can be good even if not creative.
Improve **Planning is a key skill but knowledge needed to develop the skill.** **Agree that K & S are related**	I'm here because I want to be & chance to improve skills and knowledge is great. Advice and guidance from teachers is key. Planning and time management much improved plus learning how to be a leader or motivator without being bossy is better. Of course I wish to improve and this course is helping.	By doing you gain experience – gives improved ability. More about being taught how than what – the application of knowledge to improve skills and abilities. A better focus now on what I need to do, planning is seen now to be key. The teaching helps a lot to fill out gaps in my knowledge.	Teaching has improved knowledge rather than skills. I am not good at planning even though you gave me the info at the beginning. Personal planning is good though. Knowledge and skills are related so these are improving.	The teaching has helped me to see knowledge as interdependent to develop skills. I rely more on own ability now than I did when I started. This is something I have learned. I am a better planner than before. Yes, I wish to improve.	I think one relies on the other so both have improved.	No doubt skills are needed but overall I wish to gain improvement all round.

Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
Thinking **More use of thinking to plan. Supports above.**	I think more at the start of a task now than I used to do. Group working is much improved.	I know that I need to think more about things before jumping in. I will not rely blindly on what others are saying. I reflect more than I used to.	Creative style has opened up my thinking quite a lot from before. I think people will choose something familiar.	Thinking follows a similar pattern to before, I would accept what the lecturer says but now I am starting to question a little more. I am more willing to try new things but not too far from previously.		
Reflective thinking stated to be higher but neither cohort show this.	This depends on the context – cultural aspects are important to consider and are more consolidated.	Yes, I reflect more & also have improved my critical evaluation too. Cultural aspects consolidating more.	More reflective overall but I also do read more and more carefully as well.	More reflective in general but I also recognise the need to read more carefully now.	I think my thinking style has not really changed.	Yes, I reflect more and also have improved my critical evaluation too.

Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
Learning **Tendency towards improved decision making and self-reliance**	My learning style has developed through the course quite a lot. I have learned how better to approach prep and assignments.	I do more reading rather than cram for exams. Opened my eyes to rely more on my own desire to learn through more research-based info gathering. Understanding is better as I use more discussion before action.	Big change for me in the way I learn from a formulaic method to thinking more about what I want to do, making my own decisions. Used to a lecturing style but creative lessons are tiring – lots of thinking needed.	Lectures and labs was previous experience. Creativity aspects were covered before so a little bit different but not much. Pure lectures/interactive sessions should be tailored to the taught material. Case studies are good.		
Improved reliance on self to ask Q's and clarify – is it use of language? All said yes to discussion and Q's in class.	Asking questions and discussing in class is good. I have gone back to making check lists to ensure I am ready for the next class.	Asking questions and discussing in class is good. Interaction with tutors allows more learning, more productive/effective.	Asking questions and discussing in class is good. I now read more before coming to class – adapted & better preparation.	Asking questions and discussing in class is good. I have learned to not expect spoon feeding and do more preparation.	Asking questions and discussing in class is good. I gain more confidence to speak up and feel safer, not lose face if I am wrong.	Asking questions and discussing in class is good. I have increased belief & trust by being able to ask for further guidance and confirm understanding.

Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
Self-Esteem **Generally more confident**	Quite confident in the past but not sure about working with other people. I am quite confident now in my abilities.	I always listen to others before saying my own thoughts. I now understand the need for this is very important especially in group working.	Nervous about the future but know what to expect. This changed a little I become more confident generally but not in planning.	I am more confident, teacher teaches me the theory but helps me to see what else was needed for me to improve in skills.		
Confident in planning and time mgmt.	I feel more confident in my ability to manage my time and balance conflicting requirements.	I feel more confident in my flexibility to plan and this has improved my ability to manage my time. Collaborative working is useful.	I have certainly more confidence to rely on myself. Results have given me greater belief in myself to do things and be more flexible.	Not sure if teaching caused this but the more experience I get in living in the UK the more confidence I have to make plans and stick to them.	Most aspects have stayed the same but more confident asking questions in lectures. I have changed my approach to lectures and assignments.	Practice is the key to confidence. More structure and better time management. More examples and practical case studies helps.

Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
Self-Efficacy **Planning identified as an improved skill**	Teaching has helped guide group working as decisions are made more easily. This is based on my past experience but using the new knowledge and skills gained I am more reliant on myself that I can achieve at a high level.	I have developed the ability to approach new tasks through further research, planning and preparation. I think of steps to the future (planning) now rather than waiting for things to happen. I have just started doing this & already recognise its value.	Writing in particular I find reliance on myself is better now.	I am clear that I need to do my own research outside of the lessons. Case studies are a very good thing to help clarify the reading and private study materials.		
More reliant on self is the key output not just planning.	More realistic in my aspirations and more reliant on myself but my aims have risen due to marks giving me encouragement.	More realistic in what I want – the course is a lot harder than I thought. Work smart - the teaching has given confidence.	Really changed, aims have risen – the course is harder than I thought it would be but more reliant on myself.	Masters is hard and now realise what I might achieve. Marks have helped me to believe more in myself.	More realistic in my abilities now results are coming in – the course is hard - more than I thought it would be.	More realistic in my aspirations – the course is a lot harder than I thought but the teaching has given confidence.

Category	EU Female	EU Male	Chinese Female 1	Chinese Female 2	Chinese Male	South American Male
General thoughts on teaching style **Passive OK but would have liked active**	I would be more happy to do in lesson discussions now rather than straight lecturing. I would prefer to get theory to read and then do case study discussion in class for clarification.	The questionnaire was OK but I didn't know some of the words in the final question so picked the ones I did know! I am used to straight lectures but I can see where more discussion and creativity could be useful.	Questionnaire was a little long but some not necessary. Some of the words at the end I did not understand so I chose the familiar ones. Group working is not always easy.	I am happy about your questions but I worry about my assessments so I hope I can do plenty of examples and get lots of feedback.		
Active key to promote discussion	Active works for all students in different ways - culturally.	Assignment structure and active discussion for research helped.	Active gives Chinese students freedom to relax and improve.	Better to be active teaching	With so few lectures, being encouraged to discuss is crucial.	Debating, role play, defending your position feels more important.

Appendix 12 – Teaching approaches adopted during this research

The following pedagogical approaches were adopted by the researcher when delivering the teaching intervention between pre and post teaching data collections. It was felt useful to outline the approaches used to help support the methodology.

Cohort 1 – Passive/Didactic teaching used.	Module	Approach
Undergraduate cohort (first year total of 120 students in the cohort) Postgraduate cohort (MSc one year taught total of 41 students in the cohort)	Engineering Design (A project module done as a group – the taught component during Term 1 – practical aspects during Term 2 and outside the scope of this research). Engineering Project Management (taught only, assessment at the end of the taught material i.e. after Term 1).	Straightforward lectures for 9 weeks. Flat lecture theatre location for both cohorts. Usually powerpoint slides. Some use of whiteboard. No pre-reading. Students took notes. No lecture recordings were captured but students could use their own recording devices if they wanted. Questions were allowed from the students during lecture but not prompted by the lecturer. Questions were prompted at the end of each lecture as standard procedure for final clarification.

Cohort 2 – Active flipped classroom teaching used.	Module	Approach
Undergraduate cohort (first year total of 120 students in the cohort) Postgraduate cohort (MSc one year taught total of 57 students in the cohort)	Engineering Design (A project module done as a group – the taught component during Term 1 – practical aspects during Term 2 and outside the scope of this research). Engineering Project Management (taught only, assessment required at the end of the taught material i.e. after Term 1).	Interactive lectures for 9 weeks. Flat lecture theatre location for both cohorts. Use of some powerpoint slides, case study examples, flip charts, video, whiteboard. Pre-reading required for all except the first lecture. Students encouraged to make notes. No lecture recordings were captured but students could use their own recording devices if they wanted. Group activities facilitated by the lecturer. Questions and debate encouraged intra and inter group prompted by the lecturer when activity dropped off. Summing up during and at the end of each session to link to learning outcomes plus setting of pre-reading for the following weeks' in-class discussion. Groups encouraged to get together and discuss outside of class time.