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# Measuring the success of changes to existing Business Intelligence solutions to improve Business Intelligence reporting

Evaluating the success of changes to an existing Business Intelligence (BI) environment means that there is a need to compare the level of user satisfaction with the original and amended versions of the application. The focus of this paper is on producing an evaluation tool, which can be used to measure the success of changes to existing BI solutions to support improved BI reporting. The paper identifies the users involved in the BI process and investigates what is meant by satisfaction in this context from both a user and a technical perspective. The factors to be used to measure satisfaction and appropriate clusters of measurements are identified and an evaluation tool to be used by relevant stakeholders to measure success is developed. The approach used to validate the evaluation tool is discussed and the conclusion gives suggestions for further development and extension of the tool.

Keywords: business intelligence; measuring success; user satisfaction; technical functionality; reporting systems.

# 1 Introduction

Improved decision-making (Popovič, Turk & Jaklič, 2010), competitive advantage (Marchand & Raymond, 2008; Thamir & Poulis, 2015), increased profit and efficiency (Olszak & Ziemba, 2006) are some of the potential benefits of improving the performance of analytical applications, such as Business Intelligence (BI), within an organisation. However, to measure the success of changes to existing applications, it is necessary to evaluate the changes and compare satisfaction measures for the original and the amended versions of that application. In this paper we extend our previous work on an evaluation tool to evaluate the satisfactoriness of changes to existing BI reporting solutions (Dedić & Stanier 2016b) by defining categories of users and detailing the development and validation of the evaluation tool. The initial motivation for this research was provided by an investigation into the user and technical issues involved in supporting multilingualism (ML) in BI. Developing a solution to the problem of ML (Dedić & Stanier 2016a), required a mechanism to measure the success of the proposed solution. A further motivating factor is that Information Systems (IS), which includes BI, are under constant pressure to justify their value to the organisation (Sedera & Tan, 2005). The evaluation tool presented in this paper can be used to provide measures to demonstrate the benefit of BI changes and updates.

The rest of this paper is structured as follows: section 2 discusses BI and BI reporting and gives the context for the research. Section 3 reviews existing strategies and tools for measuring success when making changes to BI systems. Section 4 discusses the development of the evaluation tool. Section 5 discusses the evaluation and validation process, while section 6 presents conclusions and suggestions for future work.

# 2 The BI context

Business Intelligence (BI), in the sense that the term is used today, emerged in the 1990s and was initially used to describe activities and tools associated with the reporting and analysis of data stored in data warehouses (Kimball et al, 2008). There are a number of definitions of BI with most definitions emphasising different aspects of the BI environment (Golfarelli, Rizzi & Cella, 2004; Lönnqvist & Pirttimäki, 2006; Dekkers, Versendaal & Batenburg, 2007; Jourdan, Rainer & Marshall , 2008; Brannon, 2010, Jamaludin & Mansor, 2011). In this paper, partly based on the definition given by Turban et al (2010), we regard BI as an umbrella term which includes the strategies, processes, applications, data, products, technologies and technical architectures used to support the collection, analysis, presentation and dissemination of business information (Dedić & Stanier, 2016b).

BI can be used to extract meaningful information and hidden knowledge to assist business stakeholders in a variety of predictions, calculations and analysis (Kurniawan, Gunawan & Kurnia, 2014). In the BI environment, data presentation and visualisation takes place at the reporting layer in the form of BI reports, dashboards or queries. The reporting layer provides users with meaningful data (Mykitychyn, 2007) and is a core concept in BI (Imhoff et al, 2003; Inmon, 2005; Gluchowski & Kempner, 2006; Watson & Wixom, 2007; Kimball et al., 2008; Baars and Kemper, 2008; Ranjan, 2009; Chu, 2013; Anadiotis, 2013; Obeidat et al, 2015).

# Section 3 Measuring the Success of changes to the BI environment

## 3.1 Defining Success in a BI context

This paper is concerned with measuring the success of modifications to an existing BI environment to improve the functionality and usability of existing BI reports. For the purposes of this paper, we adapt the definition provided by Işik, Jones & Sidorova (2013) and understand success as the positive BI reporting benefits the organisation could achieve if modifications were implemented to the BI environment. BI modifications are considered successful only if they provide or improve a positive reporting experience for users.

There is a need to define the criteria to be used as measurements of success in this context. DeLone and McLean (1992) proposed the well-known D&M IS Success Model to measure Information Systems success. According to Sabherwal, & Chowa (2006), the D&M model was based on a comprehensive literature survey but was not empirically tested. In their initial model (DeLone, & McLean, 2003), which was later slightly amended (Petter, DeLone & McLean, 2013), DeLone and McLean aimed to synthesize previous research on IS success into coherent clusters. The D&M model, which is widely accepted, considers the dimensions of *information quality*, *system quality*, *use*, *user satisfaction*, *organisational* and *individual aspect*. The most current D&M model provides a list of IS success variable categories identifying some examples of key measures to be used in each category (Petter, DeLone & McLean, 2013); for example, the variable category *system quality* could use measurements such as ease of use, system flexibility, system reliability, ease of learning, flexibility and response time; *information quality* could use measurements such as relevance, intelligibility, accuracy, usability and completeness; *service quality,* measurements such as responsiveness, accuracy, reliability and technical competence; *system use*, measurements such as amount, frequency, nature, extend and purpose of use; *user satisfaction* could be measured by a single item or via multi-attribute scales; *net benefits* could be measured through increased sales, cost reductions or improved productivity. To identify the IS success variables and CSFs relevant in the context of changes in BI reporting, there must be a focus on BI activities, phases and processes.

Lönnqvist and Pirttimäki (2006) propose four phases to be considered when measuring the performance of BI: (1) *identification of information needs*, (2) *information acquisition*, (3) *information analysis*, and (4) *storage and information utilisation.* The first phase considers activities related to discovering the business information needed to resolve problems, the second relates to the acquisition of data from heterogeneous sources and the third to the analysis of the data and conversion to information products (Lönnqvist & Pirttimäki, 2006). The first three phases are outside the scope of this paper as the focus is on BI reporting. However, the fourth phase, namely *storage and information utilisation*, is relevant to the discussion on changes in BI reporting as this phase is concerned with the storage, retrieval, sharing and use of knowledge and information through BI technologies, such as queries, reports and dashboards. This covers two clusters of measurements, those relevant to business/end-users satisfaction, and those relevant to technical functionality.

## 3.2 Business/End User Satisfaction

User satisfaction is one of the most extensively used measures in the evaluation of IS systems (Sedera & Tan, 2005), is widely recognised as a critical measure of IS success (DeLone & McLean, 1992, 2003; Davison & Deeks, 2007; Chung-Kuang, 2012; Dastgir & Mortezaie, 2012; Rahman, 2013; Petter, DeLone & McLean, 2013; Dedić & Stanier, 2016b) and has been used as a surrogate measure of IS effectiveness (Gatian, 1994). User satisfaction has been defined as “an affective attitude towards a specific computer application by someone who interacts with the application directly” (Doll & Torkzadeh, 1988, p.261). For example, positively influencing the end user experience, such as facilitating easier decision-making, can lead to a positive increment in user satisfaction. User satisfaction is also seen as the sum of feelings or attitudes of a user toward numbers of factors relevant for a specific situation (Bailey & Pearson, 1983). In a BI context, Data Warehouse (DW) performance needs to be acceptable to the end user community (Rahman, 2013). To be regarded as successful, BI solutions, such as reports and dashboards, need to meet criteria that lead to positive user satisfaction.

### **3.3 Identifying Users**

It is important to define what is meant by user in this context. Davis & Olson (1985) distinguished between two groups of users: users making decisions based on outputs from the system, and users entering information and preparing system reports. According to Doll & Torkzadeh (1988) end-user satisfaction in computing can be evaluated in terms of both the primary and secondary user roles, thus, they merge these two groups defined by Davis and Olson (1985) into one. However, in modern BI and DW, user is a more complex concept than that defined in the previous century and in developing the evaluation tool, it was necessary to define the users, and user roles, which would be relevant when assessing whether reporting changes led to user satisfaction.

Following an analysis of staff roles in eight large European companies using BI, and based on feedback from BI and DW domain experts, 4 groups and 10 different user roles relevant to BI were identified. For consistency, as roles are named differently in different companies, the categorisation is based on activities. Table 1 presents user groups and roles, and descriptions of associated activities.

Table 1: User groups, roles and relevant activities in Business Intelligence

|  |  |  |
| --- | --- | --- |
| User group | User role | Activities |
| Business  | Management | - Use reports & dashboards to make decisions at enterprise level; |
| Business | Business Users | - Use reports & dashboards to make decisions at lower levels (departments, cost centres, etc.);- Use reports & dashboards for operational and everyday activities (controlling, planning, etc.); - Control the content of the reports & dashboards and require changes or corrections if needed; - Optimal participation in Business Intelligence Competency Centre (BICC) activities; |
| Organisational | Key Users | - Communicate requirements of Business Intelligence (BI) reports and systems between business and technical groups of users;- Communicate BI project implementation phases between business and technical groups of users;- Actively participate in BICC activities; |
| Organisational | BI Team Manager | - Organisation, motivation and further development of BI team;- Anticipatory care of new projects and technologies in the field of BI; - Monitoring and optimization all BI Team quality-related processes and procedures;- Control cost of BI resources and work on profit maximisation;  |
| Organisational | Project Manager | - Communication, organisation and supervision of the BI project implementation phases with technical users;  |
| Conceptual | BI Architect  | - Define BI strategy and processes at enterprise level;- Analyse and design architecture of BI environment;- Ensure compliance of BI architecture with other enterprise systems;- Initiate, develop and/or lead BICC; |
| Conceptual | BI Solution Designer | - Analyse and design BI system components and applications;- Communicate design of BI system components and applications to Project Managers and technical users for further implementations;- Define development standards and naming conventions in cooperation with other technical users, such as BI Product Manager;- Actively participate in BICC activities; |
| Technical | BI Application or Product Manager | - Manage BI applications from the technical perspective, such as dealing with processes, upgrades and other technical issues; - Work on continuous improvement to BI applications and systems, such as analysing current problems and identifying opportunities for optimization;- Implement objects, modules, functions and procedures required by BI system or other BI applications;- Actively participate in definition of development standards and naming conventions from software or tool perspective; - Optional participation in BICC activities; |
| Technical | Report Developer | - Develop reports according to Solution Designer specification;- Communicate implementation status with BI Solution Designer, Project Manager and BI Application or Product Manager; - Actively participate in definition of development standards and naming conventions from Reporting perspective;  |
| Technical | Data Warehouse Developer | - Analysis, design and implementation of Data Warehouse (DW) environment, such as ETL processes, transformations, staging areas and data marts;- Communicate implementation status with Report Developer, Project Manager, BI Solution Designer and BI Application or Product Manager and other IT people responsible for source systems; - Actively participate in definition of development standards and naming conventions from DW perspective;  |

Measuring user satisfaction with BI reporting processes requires insights from those using reports to make business decisions or complete operational activities and also requires technical elements to be taken into account, Thus, the user roles Management and Business Users, together with the Technical User role, are relevant to the evaluation of the effectiveness of changes to the BI environment. .

## 3.4 Measuring end user satisfaction

Doll and Torkzadeh developed a widely used model to measure End User Computer Satisfaction (EUCS) that covers key factors relating to the user perspective (Doll and Torkzadeh, 1988; Chung-Kuang, 2012). The approach includes twelve attributes in the form of questions covering five aspects of satisfaction: *content, accuracy, format, ease of use* and *timeliness*. This model is well validated and has been found to be generalizable across several IS applications; however, it has not been validated with users of BI (Chung-Kuang, 2012). Petter, DeLone & McLean (2013) provide several examples of measuring user satisfaction as part of IS success based on the D&M IS Success Model. In this approach, single items can be used to measure user satisfaction, or semantic differential scales can be used to assess attitudes and satisfaction with the system, or multi-attribute scales can be used to measure user information satisfaction. However, in the context of evaluating user satisfaction with changes to BI reporting systems, three issues have been identified with this approach. First, the discussion is about methods of measuring, rather than relevant measurements; Petter, DeLone & McLean (2013) focus on how measuring is done rather than on what is measured. The second issue is that this approach is designed for IS rather than the narrower spectrum of BI. As IS is a higher-level concept that encompasses BI, the approach covers a wider spectrum of measurements and goes beyond the BI scope and requirements. The third issue is that, in the context of evaluating the success of changes to BI reporting, the approach does not identify explicit measurements and there is no clear definition of what to measure in the given scenario. Considering the D&M model in the context of this paper, *ease of use* and *flexibility* are identified as the measures of *system quality* which may be relevant.

In the Data Warehouse Balanced Scorecard Model approach (DWBSM), the user perspective, understood as user satisfaction with data quality and query performance is defined as one of four aspects to be considered when measuring the success of the DW (Rahman, 2013). The DWBSM considers data quality, average query response time, data freshness and timeliness of information per service level agreement as key factors in determining user satisfaction. As data warehouses are at the heart of BI systems (Olszak & Ziemba, 2006; Dedić & Stanier, 2016a), these factors are relevant to the evaluation of the success of changes to BI reporting, but are not comprehensive enough as they cover only the DW element of a BI system.

Elements from different approaches were combined to develop a tool for measuring user satisfaction with changes to BI reporting systems. As the EUCS model is well validated and widely used, EUCS was used as a basis for the user satisfaction element of the measurement tool. Aspects and attributes from the EUCS model were cross tabulated with the phases proposed by Lönnqvist and Pirttimäki (2006). Table 2 shows the results of the cross tabulation with areas of intersection marked with ‘✓’. Categories and questions in the left-hand column of Table 2 present aspects and attributes from EUCS model. The numbers in the right-hand column relate to the four phases ((1) *identification of information needs* (2) *information acquisition*(3) *information analysis* (4) *storage and information utilisation)* proposed by Lönnqvist and Pirttimäki for use when measuring the performance of BI systems.

**Table 2.** Cross-tabulation of EUCS attributes and phases of measuring BI performance

|  |  |
| --- | --- |
| EUCS aspects and their attributes (Doll and Torkzadeh, 1988) | Phases of measuring BI performance (Lönnqvist and Pirttimäki, 2006) |
| **1st**  | **2nd**  | **3rd**  | **4th**  |
| Content | Does the system provide the precise information you need? | ✓ | ✓ | ✓ |  |
| Does the information content meet your needs? | ✓ | ✓ | ✓ | ✓ |
| Does the system provide reports that seem to be just about exactly what you need? | ✓ | ✓ |  |  |
| Does the system provide sufficient information? | ✓ | ✓ |  |  |
| Accuracy | Is the system accurate? |  |  |  | ✓ |
| Are you satisfied with the accuracy of the system? |  |  |  | ✓ |
| Format | Do you think the output is presented in a useful format? |  |  |  | ✓ |
| Is the information clear? | ✓ |  | ✓ |  |
| Ease of use | Is the system user friendly? |  |  |  | ✓ |
| Is the system easy to use? |  |  |  | ✓ |
| Timeliness | Do you get the information you need in time? |  |  |  | ✓ |
| Does the system provide up-to-date information? |  |  |  | ✓ |

As discussed in section 3.1., only the *storage and information* utilisation phase (phase 4 in Table 2) from the Lönnqvist and Pirttimäki approach is considered relevant when measuring the success of changes made to BI reporting systems, meaning that the focus in Table 2 is on the intersection of EUCS elements and phase 4. The eight key measures identified for phase 4 in Table 2 were adapted for use in a BI context and used as the basis for a user satisfaction questionnaire. This follows the EUCS model which also uses a question based approach. Table 3 presents the questions developed from Table 2; the questions themselves were later revised following feedback during the initial phase of validation.

**Table 3.** User satisfaction questions

|  |  |
| --- | --- |
| 1 | Does the information content of the reports meet your needs? |
| 2 | Are the BI system and reports accurate? |
| 3 | Are you satisfied with the accuracy of the BI system and the associated reports?  |
| 4 | Do you think the output is presented in a useful format? |
| 5 | Are the BI system and associated reports user friendly? |
| 6 | Are the BI system and associated reports easy to use? |
| 7 | Do you get the information you need in time? |
| 8 | Do the BI system and associated reports provide up-to-date information? |
| 9 | Are you satisfied with the changing descriptive content (CDS) functionality? |
| 10 | Is the BI system flexible enough regarding CDS functionality? |
| 11 | Is CDS functionality fast enough to fulfil business requirements in a timely fashion?  |

The EUCS elements were extended to include three additional questions related to changing the descriptive content (CDS) of BI reports. CDS issues are common with large and rapidly changing dimensions (Dedić & Stanier, 2016a) and are a significant issues in managing BI reporting. Descriptive content is conventionally known as *master data* and is used to describe entities, which are independent of, and fundamental to, enterprise operations such as products, persons, customers, locations, suppliers, or services (Talburt & Zhou, 2015). An example of descriptive content (*master data*) is provided in Figure 1, in the Country, Assortment Group and Article columns. The most common cause of CDS change requests are errors in the descriptions.



Figure 1: Example of descriptive content in BI report

### 3.5 Measuring technical functionality.

The nature of BI systems mean that user satisfaction alone is not a sufficient measure of success and it is also necessary to consider technical factors. *Reporting & BI query runtime* was identified from the DWBSM approach (Rahman, 2013) as relevant in the context of BI reporting. From the D&M IS success model (Petter, DeLone & McLean , 2013), the *response time* measure was extracted from the *system quality* cluster of IS success variables. *Reporting & BI query runtime* and *response time* both belong to the cluster of measurements dealing with the time and were evaluated from a BI reporting perspective to identify appropriate measurements. Table 4 shows the elements identified as a result of this process and includes additional elements identified empirically, related to memory use and technical scalability.

**Table 4.** Technical measurements

|  |  |
| --- | --- |
| 1 | Initial BI report or dashboard execution time |
| 2 | Query execution time  |
| 3 | Re-execution time when changing report language, currency or unit |
| 4 | Time required to change erroneous descriptions of descriptive attributes / hierarchies |
| 5 | Database memory consumption |
| 6 | CPU memory usage during execution of: a) Initial BI report or dashboard; b) Query; c) Re-execution of report when changing language, currency or unit; |
| 7 | Technical scalability and support for integration of proposed solution in regard to existing environment |
| 8 | Flexibility and extensibility in regard to possible extension of the system in the future |
| 10 | Is the BI system flexible enough regarding CDS functionality? |
| 11 | Is CDS functionality fast enough to fulfil business requirements in a timely fashion?  |

# 4 Development of the Evaluation Tool

From the literature, two clusters of measurements, one relating to end user satisfaction and one to technical factors, were identified. Determining the success of changes requires the same measurements to be taken first in the existing BI environment pre-change, and secondly, in the new environment, after modification of the system. The results can then be compared and used for evaluation. The end user and technical measures were combined into a single evaluation tool, in the form of a questionnaire. The evaluation tool was tested in a pilot survey with 10 BI domain experts/report users and following the pilot, a number of revisions were made: questions 2 and 3 were merged, the wording of questions 5 and 6 was modified and the original question 9 was removed. In response to comments, two additional questions, one user focused, one technical, were added. The user question related to the exporting and sharing of content functionality; the technical question related to the speed of execution time when drilling-down, conditioning, removing or adding columns in reports. The final list of factors is shown in Table 5.

## 5 Validation of the Evaluation Tool

The evaluation tool was validated in two ways, through a survey of BI users and through case study evaluation in an implementation context.

### **5.1 Survey of BI users**

Thirty users working in the BI field took part in the survey. Respondents were selected through a professional network. Fourteen of the respondents were business users with a technical focus; sixteen were business users having an exclusively business focus. All users completed the user factors element of the survey. Technical functionality may be relevant only for technical users; hence this part of survey was optional and completion depended on the respondent’s expertise. A Likert scale was used, scoring each factor on a scale of 1 – 5 (where 1 is less important and 5 is most important). In the original Likert scale approach, responses are combined to create an attitudinal measurement scale, supporting data analysis on the combined results (Boone & Boone, 2012). However, the intention in this paper was to score each individual question or statement separately and to examine the views of users regarding each separate factor. Likert-type items fall into the ordinal measurement scale, thus mode or median are recommended to measure central tendency (Boone & Boone, 2012). The results of our survey are presented in Table 5 , and are grouped into two clusters of measurements, namely user satisfaction and technical functionality.

Table 5 shows that for the user satisfaction section, no question had mode or median value less than 4, indicating that the factors identified in each question were considered important. For the technical factor section, no question had a mode or median value less than 3, indicating that all the technical factors identified were seen as relevant. As expected, a larger percentage of users with a technical role commented on technical aspects than users with a business orientation. Users with a greater business orientation rated user satisfaction questions as more important than users with a greater technical role, and the same effect was found in relation to users with a greater technical role commenting on technical functionality factors.

Table 5. Survey results based on Likert-type items

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Business Users*** | ***Technical Users*** | ***All Users*** |
| ***User Satisfaction*** | *Nr.* | *Mode* | *Median* | *Nr.* | *Mode* | *Median* | *Nr.* | *Mode* | *Median* |
| - Information content meets your needs? | 16 | 5 | 5 | 14 | 5 | 5 | 30 | **5** | 5 |
| - The information provided in the reports is accurate? | 16 | 5 | 5 | 14 | 5 | 5 | 30 | **5** | 5 |
| - Output is presented in a format that you find useful? | 16 | 5 | 5 | 14 | 4 | 4 | 30 | **5** | 4 |
| - The system and associated reports are easy for you to use? | 16 | 5 | 4.5 | 14 | 4 | 4 | 30 | **5** | 4 |
| - Information in the reports is up to date? | 16 | 5 | 5 | 14 | 5 | 5 | 30 | **5** | 5 |
| - Reports have the functionality that you require? | 16 | 5 | 4.5 | 14 | 4 | 4 | 30 | **4** | 4 |
| - The BI system is flexible enough to support easy change of \*descriptive content"\*? | 16 | 4 | 4 | 14 | 4 | 4 | 30 | **4** | 4 |
| - Is the change of "descriptive content"\* fast enough to fulfil business requirement? | 16 | 4 | 4 | 14 | 4 | 4 | 30 | **4** | 4 |
| - Exporting and sharing content functionalities meet your needs?  | 16 | 5 | 4.5 | 14 | 3 | 3 | 30 | **5** | 4 |
| ***Technical Functionality*** |  |  |  |  |  |  |  |  |  |
| - Speed of execution time for Initial BI report or dashboard | 10 | 4 | 4.5 | 13 | 4 | 4 | 23 | **4** | 4 |
| - Speed of execution time for SQL query | 8 | 4 | 4 | 13 | 4 | 4 | 21 | **4** | 4 |
| - Speed of re-execution time when changing report language, currency or unit | 11 | 4 | 4 | 13 | 4 | 4 | 24 | **4** | 4 |
| - Speed of execution time when drilling-down, conditioning, removing or adding columns in reports | 10 | 4 | 4 | 13 | 5 | 4 | 23 | **5** | 4 |
| - Amount of Time required to change erroneous descriptions of descriptive attributes and hierarchies | 7 | 3 | 3 | 12 | 3 | 3.5 | 19 | **3** | 3 |
| - Database memory consumption | 4 | 4 | 3 | 13 | 3 | 3 | 17 | **3** | 3 |
| - CPU memory usage during execution of initial BI report or dashboard | 3 | 3 | 3 | 12 | 3 | 3 | 15 | **3** | 3 |
| - CPU memory usage during execution of SQL query | 4 | 4 | 4 | 12 | 3 | 3 | 16 | **4** | 3.5 |
| - CPU memory usage during re-execution of report when changing language, currency or unit | 4 | 4 | 3 | 12 | 4 | 3 | 16 | **4** | 3 |
| - Technical scalability of proposed solution in the existing environment | 6 | 4 | 4 | 13 | 5 | 4 | 19 | **5** | 4 |
| - Support for possible extension of the system in the future | 7 | 3 | 4 | 12 | 4 | 4 | 19 | **4** | 4 |

The questions given in Table 5 represent the core evaluation tool. Two additional user satisfaction questions were suggested by users in free text comments, relating to the availability and accessibility of key figures and to whether support for further consolidation of existing information is available. An additional technical question relating to the platform independence of BI reports was also suggested. The evaluation tool can be extended by including additional questions and other factors as identified by stakeholders but the survey indicated that the evaluation tool covered relevant core measures.

### **5.2 Evaluation of the tool in an implementation context**

The tool presented in Table 5 was used in an implementation context to evaluate the success of a new design approach to support multilingualism in BI. In this project, two different BI environments were created, one based on the proposed design approach and one on a conventional BI design approach. This supported evaluation of the tool as users were able to use the tool in a pre and post change environment.

**5.2.1 Evaluation of User Satisfaction Cluster**

As part of the evaluation of the design approach, six business users from three different countries (Austria, Slovenia and Croatia), working for international retail companies which have BI systems, were asked to use the evaluation tool, covering questions from the *user satisfaction* cluster in Table 5, and then to evaluate the tool itself. The business users identified the questions from the *user satisfaction* cluster in the evaluation tool as appropriate and sufficient although some elements, depending on the context, might not be needed. As an example, the evaluation tool includes a question as to whether the information content meets the user’s needs, but this might not be relevant depending on the way in which BI is managed in an organisation.

**5.2.2 Evaluation of Technical Cluster**

The second part of evaluation included evaluating measurements from the technical functionality cluster from Table 5. For this purpose, technical functionality meaurements were separated into two categories: the first relating to data collected through experimentation and the second to information collected through experimentatl discussion with experts. The factors are shown in Table 7.

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Table 7: Separation of technical measurements into appropriate clusters

|  |  |
| --- | --- |
| Metrics were collected for the following elements in the pre and post change environments  | Domain Expert views |
| * Speed of execution time for Initial BI report or dashboard;
* Speed of execution time for SQL query;
* Speed of re-execution time when changing report language, currency or unit;
* Speed of execution time when drilling-down, conditioning, removing or adding columns in reports;
* Database memory consumption;
* CPU memory usage during execution of initial BI report or dashboard;
* CPU memory usage during execution of SQL query;
* CPU memory usage during re-execution of report when changing language, currency or unit;
 | * Amount of Time required to change erroneous descriptions of descriptive attributes and hierarchies;
* Technical scalability of proposed solution in the existing environment;
* Support for possible extension of the system in the future;
 |

To evaluate the technical measurements from the experimental data cluster from table 7, appropriate technical processes are executed and the results of those processes in both environments are recorded (BI systems based on newly proposed and conventional design approach). To evaluate technical measurements from domain expert views cluster, a method of experimental discussion was used. Table 8 provides coded profiles BI/Data Warehousing domain experts who took part in the evluation process for technical measurements, coming from two different countries (Austria and Germany). The technical elements included in the evaluation tool were endorsed by the technical users although one element (*Speed of execution time when drilling-down, conditioning, removing or adding columns in reports)*  was identified as a duplicate factor and was removed from the tool.

## 6 Conclusions and Further Work

The evaluation tool was developed using an iterative process and was refined and revised following comments received during validation. The results of the validation showed that the tool provides a useful mechanism for evaluating changes to BI reporting solutions and that the approach is flexible, allowing elements to be added or removed depending on the application context. The tool is designed for the reporting aspect of BI and this means it would not be appropriate when evaluating, for example, data acquisition or data modelling aspects. However, the approach used to develop the tool and the structure of the tool, means that there is scope to extend the it to other areas by mapping different elements. The evaluation tool could also be adapted for use as a benchmarking tool to support the evaluation of BI reporting software. Future work includes enhancing the tool by developing an online version to support the sharing of views and to facilitate adding or removing components.

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