The Analysis and Design of a Sustainable E-learning System for Business Intelligence Development

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Abstract

The process of developing Business Intelligence (BI) dashboards is a complex task and has a steep learning curve. The complexity of the process stems from the need to integrate several disparate applications, each with their own learning curves. Traditional paper-based learning environments do not accommodate the differing learning paces of students in higher education. An e-learning system can be used to improve the flexibility and the sustainability of the learning system due to its adaptive nature. This study reports on a heuristics evaluation and a cognitive walkthrough of the process of the development of a BI dashboard at a South African university. The study also reports on an extant systems evaluation of e-learning systems supporting the development of BI applications and dashboards. The evaluation results are used to analyse and design a sustainable e-learning system.

Key words: current learning process; e-learning; extant system evaluation; sustainability.

1. Introduction

The gaps in the education level of South Africa is partly due to the country's social and political history [1]. There is therefore a need to improve the learning system in South Africa by moving from a traditional face-to-face teaching approach to an e-learning approach [3-7], which has been the focus of a paradigm shift in education [2]. An e-learning system can assist in improving a traditional learning system by providing advantages such as knowledge enrichment with functionality like blogs, wikis and forums; increased flexibility, accessibility and convenience; improved infrastructure; cross-platform access; enhanced study environments for students; low delivery costs; ease of updating content; collaborative learning and scalability [3,7].

Students studying Information Systems (IS) related fields such as Enterprise Resource Planning (ERP), extended ERP and Business Intelligence (BI) can also benefit from the use of e-learning approaches. BI is defined as a process of capturing, accessing, understanding, analysing and transforming raw data into actionable information in order to aid quality decision making and to improve performance [7]. Extended ERP is a business strategy that supports businesses in their utilisation of industry-specific sets of applications which may include BI as a component [8]. BI consists of various tools and technologies such as digital dashboards which is a visual tool aiding strategic decision-making [9]. The learning curve of developing BI dashboards is steep and students require a significant amount of programming experience [10]. An e-learning system can therefore assist with improving the flexibility of the learning process [22]. An e-learning system for BI development is therefore required, but designers of e-learning systems should strategically consider the long-term nature of an e-learning system as well as the quality of the system, so that institutions can be assured of the sustainability of these e-learning systems [12,13].

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Whilst several studies have investigated e-learning systems [14,15], research related to the learning process of BI development is limited, particularly with regards to the development environment and the components required for a sustainable e-learning system. This study provides a valuable contribution towards reducing the gap in the literature since it provides empirical evidence of suitable features of e-learning tools for BI that can be implemented in Higher Education Institutions (HEIs). The following section discusses literature related to e-learning and the sustainability thereof, in the context of BI development. This is then followed by a discussion of the research methodology and then by an analysis of the results. The recommendations and conclusions for the study complete the paper in the last section.

2. Sustainable e-learning systems for BI development

IS students are often required to enrol in BI courses as this is a crucial skill for IS graduates [15]. BI is a process involving the conversion of data into information and information into knowledge [16], and enables managers to better understand business contexts by providing access to real-time data that enables valuable insight into the business [17]. BI consists of various tools and technologies such as digital dashboards which allow managers to see meaningful patterns within the data that would otherwise be meaningless due to the abundance of data that is usually presented to the manager [9]. A dashboard acts like a “magnifying glass” of the organisation because of the ability it gives the users to focus on highlighted areas of a business in various forms which may also be drilled-down to allow the user to see more information [18]. Developing BI tools and technologies such as BI dashboards can be a complex task and studies have shown that only 24% of BI projects were considered successful [19]. The process of developing dashboards requires the developer to have substantial programming skills and experience within many application software environments to create even the most basic visualisations [11,20]. Therefore, students may find that it is quite a challenge to integrate a variety of data sources and scattered systems, each with their own business rules and learning curves [20].

A recent trend in the field of education is e-learning which has changed learning and teaching methods drastically [22]. E-learning is the convergence of learning processes and Internet technology which has become a favourable alternative learning method in education [23]. E-learning is an umbrella term used to describe all of the technologies and tools that have been introduced into the process of teaching and learning to create an improved learning process [24]. The two main components of an e-learning system are a course management system (CMS) and an assessment management system (AMS) [25]. The CMS handles learning content such as text, video, sound and pictures. In addition to this, the AMS evaluates the student’s knowledge capability based on what was learnt from the CMS.

In order to prevent the implementation of an e-learning system becoming a tool that just sits alongside institutional practices, it is necessary for a change in the culture of the implementing institution [11]. The sustainability of the e-learning system should be strategically considered by the institution with regards to the long-term nature and quality of the system [12,13]. According to Gunn [11], an e-learning system is considered sustainable when the following three conditions are met:

- **Proof-of-concept:** The e-learning system has been through a proof-of-concept stage and has been proved to be beneficial to teaching and learning in the long-term after having been implemented within a course;
- **Potential for adoption:** The e-learning system has proven potential to be adopted, and even adapted, for use beyond the original development environment, and;

- **Sustainable maintenance:** Maintenance, the use of and further development of the e-learning system does not stay dependent on the individuals that created it so that if their future contribution ceased, the future of the e-learning initiative would not be compromised.

A sustainably developed e-learning system aims to transform the current methods of teaching and learning, and the way in which HEIs function [12,13]. In the same way that e-learning systems should be sustainable, they should also promote sustainability. Sustainability is achieved by using e-learning systems to distribute learning material electronically, thereby eliminating the need to print learning material which is prevalent in the traditional learning environment [22]. E-learning can promote sustainability by enabling students to access the system from any location, thereby saving transportation costs [15,22]. Therefore, it can be deduced that e-learning systems should be both sustainable and promote sustainability.

The increase in demand at HEIs for e-learning initiatives has warranted the need to evaluate existing learning processes in order to ensure that an e-learning system is sustainably implemented to ensure its longevity [14], and the benefits associated with the e-learning system [26]. Three factors for designing effective and sustainable e-learning systems have been identified, namely the learners' self-efficacy, multimedia formats and interaction environments [27]. Learner characteristics such as self-efficacy needs to be identified and accounted for because it is necessary to understand the targeted users of the system. Multimedia formats can facilitate the creation of complex cognitive skills such as reasoning and inference. The ability for e-learning systems to adapt according to the individual user's needs is an important consideration.

A recent trend in learning approaches is gamification, which is described as the usage of game design elements in non-gaming contexts such as education [27,28]. Gamification incorporates game elements into a non-gaming software application to increase user experience and engagement [29]. It can be used to improve the participation and motivation of students to complete activities that may not previously have been attractive [27,28]. Game design elements may include the ability to rate activities, posing activities to students in the form of challenges and providing rewards or incentives for the students that complete the tasks and on the contrary, penalties or additional tasks for those who do not complete the tasks [27,29]. Learning is enhanced with gamification because the interaction time between the student and the content of the e-learning system increases substantially, the speed of browsing through courses increases and results are improved [30]. Instant feedback is an important aspect that gamification provides for students where they can observe the level of knowledge gained at the end of certain milestones, which can motivate them to improve [30]. It can be deduced therefore that gamification can support the factors of multimedia formats and interaction environments which are recommended for a sustainable e-learning system. The development of BI dashboards in educational environments can be supported with the implementation of a sustainable e-learning system that can help students resolve the problems that they may experience in the learning process [31].

3. Research Methodology

The purpose of this paper is to investigate and report on the design of a sustainable e-learning system which can support the process of developing BI dashboards. The main research question of this paper is *"How can a sustainable e-learning system be designed to support the current learning process of developing a BI dashboard?"*. In order to address the main research question, two research objectives need to be realised, namely:

RO1: Analyse the problems of existing BI learning processes; and

RO2: Determine the suitable components of a sustainable e-learning system for BI development.

In order to answer the research question, a case study approach was adopted and the current learning process of developing dashboards at a South African HEI was analysed. The process was investigated and described by means of a cognitive walkthrough. A cognitive walkthrough is a usability evaluation method in which evaluators work through a series of tasks in order to accomplish a greater task and ask a set of questions from the perspective of the user [32].

Requirements for a software system such as an e-learning system can be analysed and determined by observing and evaluating the current processes within an organisation by conducting a heuristics evaluation [28]. A heuristics evaluation is a method that aims to find usability problems that are identified as issues for the user by providing a set of guidelines with which the user compares the interface or process with in order to find the usability problems [34]. Heuristics evaluations can be used in both the design and evaluation phases of software development and can also be used to evaluate paper-based designs before creating functional prototypes. Human-computer interaction (HCI) studies show that using three to five evaluators are sufficient in determining usability problems [34]. Therefore once the cognitive walkthrough was completed, a heuristic evaluation took place in order to derive the design for the proposed e-learning system. The evaluation of the current learning process of developing BI dashboards was conducted using three participants, all of which are postgraduate students in the department of Computing Sciences (CS) at the Nelson Mandela Metropolitan University (NMMU). The ERP system used in order to develop the BI dashboard is SYSPRO which is a popular ERP vendor in South Africa [35].

The procedure of heuristically evaluating the current processes may be supplemented with the comparative evaluation of extant systems [36]. An extant systems evaluation can be used to identify suitable features for the “to-be” processes, automated by the proposed system [32,36]. From this it can be deduced that heuristics evaluations of existing processes and e-learning systems can be used for requirements analysis and design of new e-learning systems. An extant systems’ evaluation of e-learning systems was also undertaken. The insights gained from the evaluations of these systems are used to identify best practices and to determine which features would be suitable for incorporation into the design of a sustainable e-learning system for BI dashboard development [32,36].

4. Results of the analysis of the current learning process

The results of the cognitive walkthrough revealed that the process of developing BI dashboards for BI students involves five high-level processes which are executed in several disparate systems (Figure 1). Participant 1 was inexperienced with regards to the development of BI dashboards, Participant 2 had some experience with developing BI dashboards and Participant 3 had substantial experience with developing BI dashboards. By using participants with varying experience levels, it is possible to discover a full range of potential problems that BI students may discover.

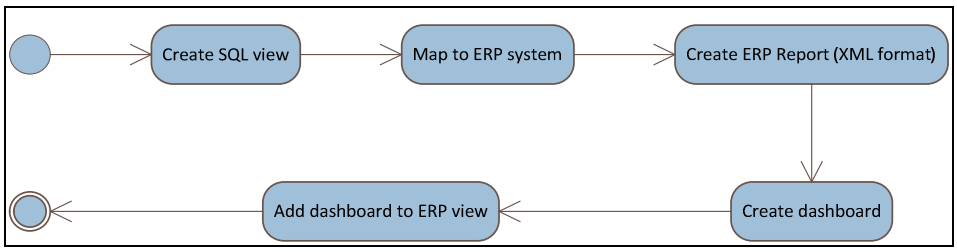

Figure 1: Activity diagram of the current process of developing a BI dashboard

At the beginning of the evaluation, the participants were provided with task instructions and a questionnaire. The participants were required to complete this questionnaire whilst developing the dashboards. The questionnaire used in the evaluation consisted of both open-ended and closed-

ended questions. The questionnaire comprised of a severity scale where participants had to identify and rate the problems that they faced in the development process. The severity scale ranged from a severity rating of 1 to 4, with 1 being a cosmetic problem; 2 being a minor problem; 3 being a major problem and 4 being a usability catastrophe. Participants were encouraged to consider Nielsen's heuristics [38] when identifying problems with the development process.

It is clear that some participants found problems with the same tasks such as the problem of *"Adding the developer tab in Xcelcius was an issue"* as discovered by Participant 1 and Participant 2 (Table 1). All three participants identified the same issue, which was *"Not enough detail when converting the report to export in XML format"* and gave it a rating of 3. None of the problems identified were rated "Cosmetic" (rating 1). There was, however, a rating of 4 allocated to one of the problems identified by Participant 1, indicating that there was a "usability catastrophe". The overall theme of the problems identified was the *"Insufficient task instructions"*. Participants struggled to complete tasks within the process due to the lack of detail in the instructions given to them.

Problem Number	Description	Task	Severity Rating		
			P1	P2	P3
1	Task instructions do not properly explain all of the steps in creating the SQL view	1 (Creating a SQL view)	3		2
2	Instructions are confusing because where it refers to "length", it is meant to refer to "edit pattern"	2 (Adding the data dictionary in SYSPRO and editing columns)	2	2	
3	Need tasks to be more broken down to make it clearer for the user	3 (Whole SYSPRO component)			2
4	**Not enough detail when converting the report to export in XML format**	**3 (Converting report to an XML file)**	**3**	**3**	**3**
5	Adding the developer tab in Xcelcius was an issue	4 (Enabling the Developer tab)	4	3	
6	Image is not clear for creating indicators for the variance column	4 (Indicators for variance column)			2
7	Could not find the data manager and needed assistance	4 (Adding a map connection with usage refresh)		2	

Table 1: Problems discovered by participants in heuristics evaluation

A post-task questionnaire was given to the participants which was based on the NASA-Task Load Index (TLX) developed by Hart and Staveland [39]. The TLX evaluation determines the workload required by a certain process or system. Participants were required to rate the frustration level, effort, performance, temporal demand, physical demand and mental demand on a 5-point Likert scale with 1 being either very low or very poor and 5 being either very high or very good.[3]

The analysis of the results of the TLX evaluation (Figure 2) indicates that two of the three participants rated Effort positively with a score of 4 (80%). From this it can be deduced that the process of developing a dashboard requires a high amount of effort. The average score of the frustration level experienced by the participants ($\mu = 2.67$) is neutral. Participant 1 rated the mental demand of the task positively, with a score of 4 out of a possible 5. It can be inferred that the task of developing a BI dashboard can be mentally demanding. One of the participants stated that it was challenging to work with new software but the instructions were vague.

[3] The following statistical ranges were applied: negative [1 to 2.6), neutral [2.6 to 3.4] and positive (3.4 to 5].

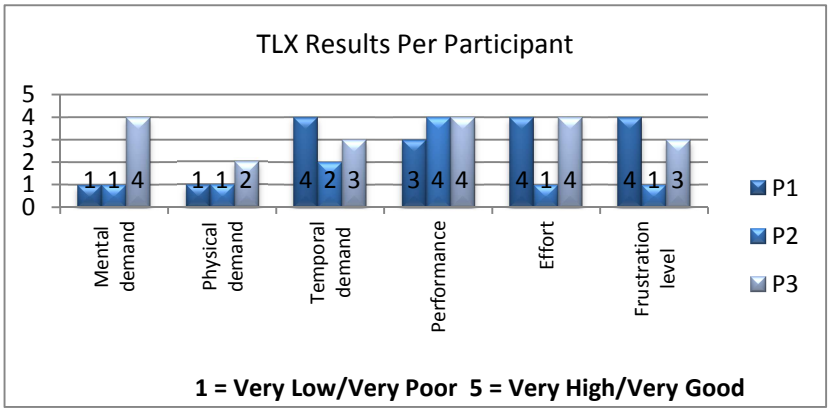

Figure 2: TLX results per participant

5. Design of sustainable e-learning system

The cognitive walkthrough revealed several problems with the existing learning process of the NMMU. In order to identify best practices for e-learning systems, an evaluation of an extant system took place. The system evaluated was the Obami platform, which has features such as: blogs, media galleries, resource repositories to newsfeeds, online chat, messages, portals, assignments, events and widgets. Obami also has a Flash Games portal where assessments test users' logic, memory, maths, language and typing skills [39]. Obami is an e-learning web-based platform that uses a gamification approach and connects users in a virtual learning environment (VLE) and is considered a social learning platform because it encourages collaboration and uses gaming aspects [40].

The literature review, usability evaluations and extant systems evaluation revealed several components required for the design of a sustainable e-learning system which can be used for the development of BI dashboards (Figure 3). The system's functionality must promote long-term benefits, be adaptive and flexible and have maintenance requirements that are not dependent on an individual [11]. The basis of the e-learning model consists of two components, namely the course management system (CMS) and an assessment management system (AMS) [25]. The features that the sustainable e-learning system must support are demonstrations, games, assessment and incentives based on gaming performance.

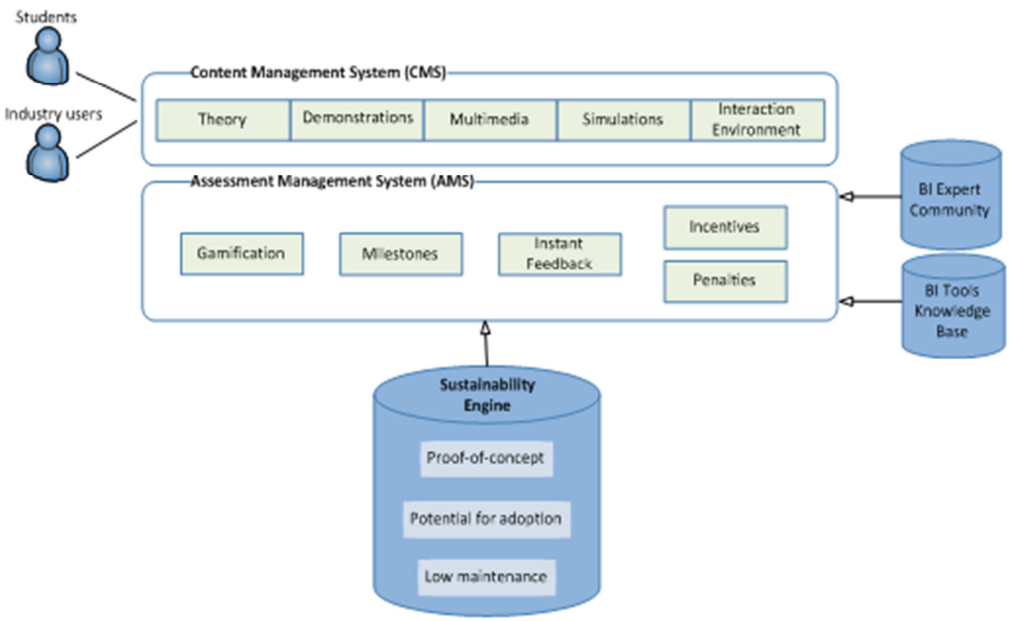

Figure 3: Sustainable e-learning model for BI development

6. Conclusions and recommendations

This study primarily aimed to report on the analysis and design of a sustainable e-learning system for BI development. A heuristics evaluation of the current learning process and an extant systems evaluation of e-learning systems supporting the development of BI applications and dashboards is reported on. Whilst the heuristics study was undertaken with a seemingly small sample of students at NMMU, the results are still very useful in identifying and understanding the problems with the current process of developing dashboards.

The results obtained from the study show that there are problems that exist with the current learning process that can be improved with the implementation of a sustainable e-learning system using gamification elements. The study provides a valuable contribution to improving the education of BI dashboard development and improves e-learning implementations in a sustainable and long-term way. However, further research needs to be conducted on the implementation of the model for sustainable e-learning as well as suitable development tools. Additional empirical research also needs to be conducted regarding the usefulness and usability of the proposed model after implementation.

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