THE EFFECTIVENESS OF SDMS IN THE DEVELOPMENT OF E-LEARNING SYSTEMS IN SOUTH AFRICA

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ABSTRACT

E-learning systems, or learning management systems, as it is known in the field, sit at the heart of educational systems and are used to systematically deliver on-line content and facilitate the learning experience around that content. It becomes essential to ensure that Learning Management Systems of a high standard are being developed. In the field of Systems Development Methodologies (SDMs), much research has been done and the value of SDMs is proven and documented. To ensure that e-learning systems of outstanding quality are being developed, it is crucial that systems development methodologies are being used as they can have a significant impact on the development process.
The main focus of this study was to determine if systems development methodologies are being utilised in the development of electronic learning systems in South Africa and if these methodologies are being applied effectively. By utilising a survey as the main research method and statistically analysing the dataset, meaningful results were obtained. Some of the findings were that academic institutions are clearly using open-source LMSs more than proprietary LMSs. The LMS platform had a moderate effect on the success of the LMS. Open-source LMS users were very satisfied with their LMS platform and not inclined to consider a proprietary LMS for future projects. Proprietary LMS users may be inclined to consider an open-source LMS for future projects. It was found that a very strong relationship exists between respondents that indicated that they use RAD as SDM and the impact this SDM had on the quality and productivity of the development process. It was found that a very strong relationship exists between the perceived support that the SDM provides and the impact of the SDM on the quality and productivity of the development process. This in turn has a strong influence on the impact systems development methodologies have on the quality of learning management systems.

KEYWORDS

e-learning, learning management systems, systems development methodologies.

1. INTRODUCTION AND PROBLEM STATEMENT

With the dramatic increase in the popularity and use of e-learning and e-learning systems, it becomes a necessity to ensure that systems of a high quality are being developed. If e-learning is applied efficiently, it can go a long way towards helping learners to generate and obtain knowledge for themselves. Many cultures around the world still have no access to even basic education. E-learning can be one of the answers to this problem.

Even a cursory study into e-learning makes it clear that there is still plenty of confusion surrounding e-learning and the technology and applications involved with it. It becomes apparent there is still much to benefit, from further research into this field.

In another and not unrelated field of Systems Development Methodologies (SDMs), much more research has been done and the value of SDMs is proven and documented. However, there is still a lack of empirical evidence on the actual use and effectiveness of SDMs and even more so with its use and effectiveness in the development of e-learning systems.

SDMs have had a major impact on the development of software systems over the last 40 odd years and are an indispensable tool for developing systems in recent times. E-learning systems, being an emerging subset in software systems technology, could well profit from the benefits SDMs have to offer.

The aim of this study will be to research the use and effectiveness of SDMs in the development of e-learning systems.

ISBN: 978-989-8704-08-5 © 2014

2. LITERATURE STUDY

2.1 Terminology

For the purposes of this study e-learning can be seen as a medium for delivering and facilitating learning, through electronic means.

The term Learning Management System will also be used for the purposes of this study. An LMS is a software system that is used to systematically deliver content on-line and to facilitate the learning experience around that content.

The following definition of a systems development methodology will be used (Huisman, 1999):

- **Systems development approach**
  This can be defined as the philosophical view on which the methodology is built. Thus, the set of goals, guiding principles and beliefs, basic concepts and principles of the systems development process that drive interpretations and actions in systems development (Iivari *et al*., 1998; Iivari *et al*., 1999). Examples of systems development approaches are the structured approach, object-oriented approach, information modelling, etc.
- **Systems development process model**
  Wynekoop and Russo (1993) define a process model as a representation of the sequences of stages through which a system evolves. Some examples of process models are the linear life-cycle model, the spiral model and incremental model.
- **Systems development method**
  A method is a systematic approach to conducting at least one complete phase of systems development, consisting of a set of guidelines, activities, techniques and tools, based on a particular philosophy of systems development and the target system (Wynekoop & Russo, 1993). Examples include IE, SSADM, etc.
- **Systems development technique**
  A systems development technique consists of a well-defined sequence of actions, ensuring successful results if used correctly (Iivari *et al*., 2000; Brinkkemper, 1996), for example entity relationship diagrams and data flow diagrams..

2.2 The Use of Systems Development Methodologies

It is argued that the use of SDMs will aid in the development process by making it more effective, secure, predictable and easier to control, whilst improving productivity and quality (Fitzgerald *et al*., 2002). Whether systems development methodologies are being used in practice has been a point of interest for academics for an extended period of time.

Russo *et al*. (1995) found that only 6% of developers followed an SDM rigorously. Chatzglou and Macaully (1996) found that 47% of their population had never used a methodology. Avison and Fitzgerald (2003) also found this number to be low. Less than 50% of organisations follow SDMs strictly (Glass, 1999). Huisman and Iivari (2006) determined that when SDMs are being used in practice, it is not to the full extent. Fitzgerald *et al*. (2002) show that the use of formalised SDMs was significantly higher in larger organisations (more than 1 000 employees) and larger IS departments (more than 20 personnel). In recent studies conducted by Brits (2011) and Janse van Rensburg (2012) it was found that 74% of organisations in South Africa make use of SDMs. Conradie (2010) and Wagener (2012) also found this number to be above 75%.

2.3 The Effectiveness of Systems Development Methodologies

Empirical research on the effectiveness of SDMs is very limited, which seems to be due to the lack of standard criteria that measures SDM effectiveness (Conradie 2010). This section will confer the results on the effectiveness of SDMs that were found in the literature.

Although many SDMs have been successfully utilised over the years, there have been many software failures, which has questioned the relevance of SDMs. Even with the use of SDMs, projects are still being abandoned halfway, still overshooting the budget, and still not being delivered within an appropriate time

frame (Truex *et al*., 2000; Gruner *et al*., 2007). However, great strides have been made in the last four decades; yet there is still much to be learned from studies into the effectiveness of SDMs.

There are several compelling reasons for using SDMs. Fitzgerald *et al*. (2002) state that systems development methodologies have been endorsed by the literature, as being capable of ensuing that the development process is more effective, secure, predictable and easier to control. Gruner *et al*. (2007) argue that it is challenging and precarious to develop software without the guidance or structured process that an SDM can provide. Huisman and Iiavari (2006) reasoned that SDMs introduce structure to the design process, thereby improving the effectiveness of software development and thus ensuing more consistent outcomes. The use of software methodologies is said to decrease the risk of failure of an information system (IS) project (Hull *et al*, 2002; Avison & Fitzgerald, 2003).

3. DATA COLLECTION AND ANALYSIS

In the field of information systems, surveys are a popular strategy to employ in the collection of empirical evidence. A questionnaire, as the measurement element, was developed in collaboration with a statistical consultation service. The constructs, identified from the conceptual research model, were operationalised by selecting measurement scale items (questions) and scale types. The questions were adapted from previous research studies, which proved to be reliable. The questionnaire was concise and relevant and contained mostly leading, importance and 5-point Likert scale questions. It was distributed electronically, as a macro-enabled Excel file, to personnel at institutions of higher education in South Africa that are responsible for developing and/or deploying e-learning systems. Software companies in South Africa, which develop e-learning solutions, were also targeted. The questionnaire had extensive built-in entry validation to ensure that the respondents fill in the correct values as well as coding to assist in data analysis.

Fifty responses were received from a possible one hundred and twenty-five responses. Therefore, the participation rate equalled 40% with 50 cases available for data analysis.

4. RESULTS OF THE RESEARH QUESTIONS

The relationship between industry and platform of the LMS (RQ1):

In academic institutions open-source LMSs are being used in almost 61% of the cases and in the private sector just above 52%. Many of the academic institutions indicated that they are in the process of moving towards an open-source learning management system but that they are currently still using a proprietary LMS.

The relationship between industry and number of students (RQ2):

Crosstab analysis was done to determine if the type of industry relates to the number of users of the specific LMS in question. The results of the crosstab analysis can be seen in Table 1 and it was statistically significant with $p < 0.01$ and a Cramer's V of 0.568.

It is quite noticeable that 75% of the academic institutions' LMSs are being utilised for 10 000 or more students, learners or employees. The private sector almost exclusively uses LMSs with more than a 1 000 users.

Table 1. Crosstab analysis: Research Question 2

Industry	Number of students/learners/employees using the LMS						
	1-99	**100-499**	**500-999**	**1000-4999**	**5000 - 9999**	**10 000 or more**	**Total**
Academic	7.1%	10.7%	0%	0%	7.1%	75%	100.0%
Private Sector	0%	15.8%	0%	21.1%	31.6%	31.6%	100.0%
Total	4.3%	12.8%	0%	8.5%	17%	57.4%	100.0%

The relationship between industry and method of procurement of LMS (RQ3):

Crosstab analysis was to determine if the type of industry relates to the LMS platform being used. The results of the crosstab analysis can be seen in Table 2 and it was statistically significant with $p < 0.05$ and a Cramer's V of 0.447. There is very little in-house development being done when it comes to the procurement of LMSs with a combined (academic and private sector) total of 17.4% of the respondents indicating that they make use of in-house development. With 32.6% of the procurement of LMSs being done by adapting open-source LMSs, it is by far the preferred method of procuring an LMS. To elaborate on the abovementioned adaption of open-source LMS, it is worth noting that 39.3% of academic institutions use open-source systems "as is", while only 5.6% of the private sector use LMSs "as is". Only 21.4% of academic institutions adapt their LMSs compared to the 50% of the private sector. A combined total of 23.9% of the procurement of LMSs are being done by purchasing off the shelf products.

Table 2. Crosstab analysis: Research Question 3

Industry	Procurement of LMSs				
	Purchased	In-house	Open-source (used as-is)	Adapted from open-source system	Total
Academic	25%	14.3%	39.3%	21.4%	100.0%
Private Sector	22.2%	22.2%	5.6%	50%	100.0%
Total	23.9%	17.4%	26.1%	32.6%	100.0%

The relationship between the LMS platform and perceived success of the LMS (RQ4):

T-tests indicated that the LMS platform had a medium effect on the success of the LMS with an effect size $\left(f^2\right)$ of 0.34 and a statistical significance, $p > 0.05$.

The relationship between the LMS platform and the satisfaction with the platform (RQ5):

T-tests indicated that the platform of the LMS has a very high effect on the inclination of respondents to consider using an open-source LMS for future projects with an effect size $\left(f^2\right)$ of 1.71 and it is statistically significant with $p < 0.001$. Respondents that use an open-source LMS would be inclined to keep using an open-source LMS for future projects with a mean value of 4.4.[1] Respondents that use a proprietary LMS will be less inclined to consider an open-source LMS for future projects with a mean value of 2.75. T-tests also indicated that the platform of the LMS has a very high effect on the inclination of respondents to consider using a proprietary LMS for future projects with an effect size $\left(f^2\right)$ of 1.04 and it is statistically significant with $p < 0.001$. Respondents that use a proprietary LMS would be inclined to keep using a proprietary LMS for future projects with a mean value of 3.65. Respondents that use an open-source LMS will be less inclined to consider a proprietary LMS for future projects with a mean value of 2.4.

The relationship between the procurement method of the LMS and the satisfaction with the platform (RQ6):

T-tests indicated that the procurement method of the LMS has a very high effect on the inclination of respondents to consider using an **open-source** LMS for future projects. Respondents that use an open-source LMS would be inclined to consider using an open-source LMS (as is, i.e. not adapting it) for future projects with an effect size $\left(f^2\right)$ of 2.16 and it is statistically significant with $p < 0.001$. Respondents that use a proprietary LMS would be inclined to consider using an open-source LMS (as is, i.e. not adapting it) for future projects with an effect size $\left(f^2\right)$ of 2.11 and it is statistically significant with $p < 0.001$. Respondents that use an open-source LMS would also be inclined to consider adapting an open-source LMS for future projects with an effect size $\left(f^2\right)$ of 1.50 and it is statistically significant with $p < 0.001$. Respondents that

[1] All the means are indicated as a value out of a possible 5, as a five-point Likert scale was used.

use a proprietary LMS would also be inclined to consider adapting an open-source LMS for future projects with an effect size $\left(f^2\right)$ of 1.45 and it is statistically significant with $p < 0.001$.

It is clear that the respondents will consider using open-source LMSs for future projects, but they are less inclined to adapt such LMSs, than using them as is.

The relationship between the perceived success of the LMS and the satisfaction of the platform (RQ7):

There is a strong relationship that exists between the success of the LMS and the satisfaction of the platform used with a Spearman's rho of 0.589 and it is statistically significant with $p < 0.001$.

The relationship between the type of SDM used and the success of the LMS (RQ8):

T-tests indicated that the use of formal SDMs had a medium effect on the success of the LMS with an effect size $\left(f^2\right)$ of 0.34 and a statistical significance, $p < 0.05$.

The relationship between the type of SDM used and the impact of the SDM on the development process (RQ9):

This research question determines if there is a relationship between the type of formal standard SDM used and the impact of the SDM on the quality and productivity of the development process. There is a very strong relationship that exists between respondents that indicated that they use RAD as SDM and the impact this SDM had on the quality and productivity of the development process. Spearman's rho = 0.618. $p < 0.001$. There is a strong relationship that exists between respondents that indicated that they use IE as SDM and the impact this SDM had on the quality and productivity of the development process. Spearman's rho = 0.517. $p < 0.01$. The SDM with the strongest influence on the quality and productivity of the development process is RAD, which is an Agile methodology.

The relationship between the performance expectancy of the SDM and the impact of the SDM on the quality and productivity of the development process (RQ10):

There is a strong relationship that exists between the performance expectancy of the SDM and the impact of the SDM on the quality and productivity of the development process with a Spearman's rho of 0.563 and it is statistically significant with $p < 0.01$.

The relationship between the performance expectancy of the SDM and the perceived impact of the SDM on the quality of the LMS (RQ11):

There is a strong relationship that exists between the performance expectancy of the SDM and the perceived impact of the SDM on the quality of the LMS with a Spearman's rho of 0.547 and it is statistically significant with $p < 0.01$.

The relationship between the perceived support that the SDM provides and the impact of the SDM on the quality and productivity of the development process (RQ12):

There is a very strong relationship that exists between the perceived support that the SDM provides and the impact of the SDM on the quality and productivity of the development process with a Spearman's rho of 0.744 and it is statistically significant with $p < 0.001$.

The relationship between the perceived support that the SDM provides and the perceived impact of the SDM on the quality of the LMS (RQ13):

There is a strong relationship that exists between the perceived support that the SDM provides and the perceived impact of the SDM on the quality of the LMS with a Spearman's rho of 0.541 and it is statistically significant with $p < 0.01$.

The relationship between the impact of the SDM on the quality and productivity of the development process and the success of the LMS (RQ14):

There is a weak relationship that exists between the impact of the SDM on the quality and productivity of the development process and the success of the LMS with a Spearman's rho of 0.177 and it is not statistically significant with $p > 0.05$.

The relationship between the impact of the SDM on the quality and productivity of the development process and the perceived impact of the SDM on the quality of the LMS (RQ15):

There is a strong relationship that exists between the impact of the SDM on the quality and productivity of the development process and the perceived impact of the SDM on the quality of the LMS with a Spearman's rho of 0.543 and it is statistically significant with $p < 0.01$.

The relationship between the perceived impact of the SDM on the quality of the LMS and the success of the LMS (RQ16):

There is a moderate relationship that exists between the perceived impact of the SDM on the quality of the LMS and the success of the LMS with a Spearman's rho of 0.376 and it is statistically significant with $p < 0.05$.

The need to design an SDM specific to LMS and the SDM that was used to design the current LMS (RQ17):

There is a strong negative relationship that exists between respondents that indicated that they use another (not listed) SDM and on opinion that there is room for a newly designed SDM specifically for developing LMSs with a Spearman's rho = -0.402 and a statistical significance, $p < 0.05$. There is a strong relationship that exists between respondents that indicated that they use another (not listed) SDM and on the opinion that an existing SDM can be adequately adopted to suit the needs of e-learning with a Spearman's rho = 0.437 and a statistical significance, $p < 0.01$. There is a moderate negative relationship that exists between the respondent that indicated that they use IE (Information Engineering) as SDM and the opinion that an existing SDM can be adequately adopted to suit the needs of e-learning with a Spearman's rho = -0.399 and a statistical significance, $p < 0.05$.

Summary of the results

A summary of the statistical analyses that were performed, and the relationships that were evaluated, can be seen in table 3.

Table 3. Research questions as tested (Note: p = Level of Significance. ***= <0.001, **= <0.01, *= <0.05, '=<0.1; n/a=this type of test could not/was not performed)

Research Question	Path tested	Spearman's rho (ρ) / Cramer's V (φ)	Effect Size (f^2)	Relationship / Correlation / Level of Association
RQ1	Industry → Platform_Used	φ_c = 0.709***	n/a	Very strong
RQ2	Industry → Number_Users	φ_c = 0.568**	n/a	Very strong
RQ3	Industry → Procurement_LMS	φ_c = 0.447*	n/a	Very strong
RQ4	Platform_Used → Success LMS	n/a	0.34	Medium effect
RQ5	Platform_Used → Satisfaction_LMS_Platform	n/a	1.71*** 1.04***	Very high effect
RQ6	Procurement_LMS → Satisfaction_LMS_Platform	n/a	2.11*** 2.16*** 1.50*** 1.45***	Very high effect
RQ7	Success LMS → Satisfaction_LMS_Platform	ρ = 0.589***	n/a	Strong
RQ8	Formal_SDM_Use → Success_LMS	n/a	0.34*	Moderate

Research Question	Path tested	Spearman's rho (ρ) / Cramer's V (φ)	Effect Size (f^2)	Relationship / Correlation / Level of Association
RQ9	Extent_Standard_SDM (RAD) → Impact_SDM_Quality_Productivity	ρ = 0.618***	n/a	Very strong
RQ10	Performance Expectancy SDM → Impact_SDM_Quality_Productivity	ρ = 0.563**	n/a	Strong
RQ11	Performance Expectancy SDM → Impact_Quality_LMS	ρ = 0.547**	n/a	Strong
RQ12	Perceived Support SDM → Impact_SDM_Quality_Productivity	ρ = 0.744***	n/a	Very strong
RQ13	Perceived Support SDM → Impact_Quality_LMS	ρ = 0.541**	n/a	Very strong
RQ14	Impact_SDM_Quality_Productivity → Success LMS	ρ = 0.177'	n/a	Weak
RQ15	Impact_SDM_Quality_Productivity → Impact_Quality_LMS	ρ = 0.543**	n/a	Strong
RQ16	Impact_Quality_LMS → Success LMS	ρ = 0.376*	n/a	Moderate
RQ17	Need_SDM_LMS → Extent_Standard_SDM (Other)	ρ = 0.437**	n/a	Strong

5. CONCLUSION

The inferential statistics that are presented in this paper reveal some interesting facts about the relationships between certain constructs related to learning management systems and systems development methodologies in South Africa.

Crosstab analysis indicated that open-source learning management systems are preferred to proprietary LMSs, especially in the academic sector. It also revealed that the majority of LMSs in South Africa are being used for 10 000 or more users. Academic institutions also tend to use open-source LMSs as is and the private sector adapts open-source LMSs to a large extent.

There is a strong relationship that exists between the perceived success of the LMS and the satisfaction of the platform used. It makes sense that respondents will be satisfied with their LMS platform if the LMS is successful. In general, respondents are very satisfied with their current LMS platform.

Open-source LMS users are not inclined to consider a proprietary LMS for future projects. Proprietary LMS users are more inclined to consider an open-source LMS for future projects. Both proprietary and open-source LMS users will be less inclined to adapt an open-source LMS, than using it as is.

A very strong relationship were found between the perceived support that the SDM provides and the impact of the SDM on the quality and productivity of the development process. There is a very strong relationship that exists between respondents that indicated that they use RAD as SDM and the impact this SDM had on the quality and productivity of the development process. This correlates with what the literature revealed on the use of Agile methodologies in the post-methodology era.

There is also a strong relationship that exists between the performance that users expect SDMs can provide and the impact that the specific SDMs have on the quality and productivity of the development process. A very strong relationship exists between the support that the SDM provides in the development process and the actual impact that the SDM has on the quality and productivity of the development process.

Both the perceived support that the SDM provides and the impact of the SDM on the quality and productivity of the development process have a strong influence on the impact the SDM has on the quality of the LMS.

The study made a contribution to the discipline of information systems, and more specifically, learning management systems, by providing insights with regard to the factors effecting the use and effectiveness of SDMs in developing LMSs. As far as could be ascertained, this study generated the first empirical data on the procurement and development of LMSs in South Africa. A holistic picture was drawn on what the South African e-learning market looks like and it was determined that the extent of use of open-source LMSs exceeds what was initially believed.

Almost 75% of the respondents indicated that there may be room for a newly designed SDM specifically for the development of LMSs and tools for LMSs. This could well be a great opportunity for future research in this field. This study may also serve as a stimulus for future research in the field of learning management systems and more specifically the development of LMSs by using systems development methodologies to enhance the chances of success for those systems.

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