TEACHERS' BELIEFS ABOUT EDUCATIONAL TECHNOLOGY AND THEIR ACTUAL USE IN THE CLASSROOM

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Abstract

In this exploratory study of 46 Mathematics and Physical Science Grade 10 – 12 teachers, we sought to examine the influence of teachers' beliefs on their intended and actual usage of educational technology in their classrooms. The educational technology used is dynamic geometry software and PhET. The technology acceptance model (TAM) was used as a framework to examine the influence of teachers' beliefs on their intention to use educational technology in their classrooms. Partial least squares analysis, indicate that beliefs about perceived usefulness has a significant effect on teachers' intention to use educational technology. This study has predicted teachers' actual usage of educational technology in their classroom with an accuracy of 78.6%.

Keywords*:* Dynamic geometry software, GeoGebra, Geometer's Sketchpad, PhET simulations, teacher beliefs, Technology Acceptance Model, mathematics, physics

Introduction

Learning with understanding is one of the hallmarks of the new science of learning (Bransford, Brown, & Cocking, 2000). Classroom environments that support understanding have to be established in order to improve students' conceptual development. Collins (1991) states that 'school work' cannot resist the change in a society where most work is becoming computer-based. Using computers could help students to make greater conceptual gains (Thomas & Emereole, 2002). Rutten, van Joolingen & van der Veen (2012) reviewed 51 articles between 2001 and 2010 and found that simulations are useful for visualisation and reported large effect sizes of well-designed simulation-based instruction. Technology can be used to strengthen student learning and enhance pedagogy (Dede, 2000) and can be used effectively as a cognitive tool for teaching and learning in the classroom (Bruce & Levin, 2001; Bransford, Brown & Cocking, 2000) but teachers' attitudes and beliefs have been identified as barriers to using technology for instruction (Hew & Brush, 2007; Nyaumwe, 2006; Albion, 2001).

Teachers hold the key to student achievement, since they influence what and how students are taught (Tobin, 1998) but teachers are resistant to change (Lumpe, Haney & Czerniak, 2000). A reason for this is because teachers' pedagogy is based on their beliefs and values and these are difficult to change. Problems can emerge when teachers' beliefs are ignored, because "beliefs and values that teachers hold drive many of the choices they make in the classroom" (Cuban, 2001, 169). Leatham (2006, 92) indicates "what one beliefs influences what one does". Cuban (2001) argues that beliefs influence what and how teachers choose to teach and what innovations they endorse or reject.

For this reason it is imperative to know what factors and beliefs influence teachers' behaviour, and what professional development programmes need to be designed to address these determinants (Haney & Lumpe, 1995). Factors and beliefs that influence teachers' behaviour were reported in two studies by Stols and Kriek (2011) and Kriek and Stols (2010) where they used the Theory of Planned behaviour to predict teachers' behaviour in Mathematics and Physics respectively. This paper explores if a prediction on actual usage of educational technology in the classroom can be made if it is known what influences teachers' beliefs by using the Technology Acceptance Model.

Theoretical framework

Technology Acceptance Model

The Theory of Reasoned Action (Ajzen & Fishbein, 1980) was used to develop the Technology Acceptance Model (TAM), as an attempt to explain factors that influence users' acceptance of information technology systems (Bagozzi, Davis & Warshaw, 1992). TAM, as explained in figure 1, currently enjoys the status of being the prime tool for testing user acceptance of new technologies (Green, 2005). This is why this study adapted TAM as theoretical framework. According to TAM, attitude towards the use of new technology are determined by two factors, the beliefs about perceive usefulness and beliefs about perceive ease of use of the technology. Beliefs about perceived usefulness is about the extent "to which a person believes that using the system will enhance his or her job performance", while beliefs about perceived ease of use is about "a person's beliefs that using the specific technology will be free of effort" (Davis, 1989, 320). According to this model attitude is the result of behavioural beliefs and the corresponding judgements about the outcomes. The problem therefore is not the attitudes of teachers, but their beliefs about the use of technology for instruction. The important role of beliefs in the use of technology for teaching has also been identified and explained by Zhao and Cziko (2001).

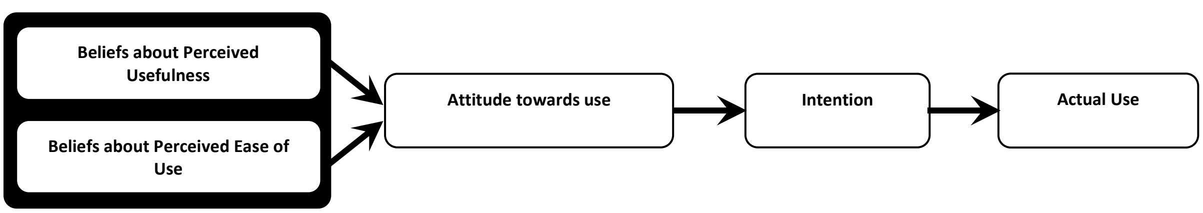

Figure 1: Technology Acceptance Model (Davis, 1989)

TAM is a well-established and influential research model in studies that seeks to understand technology acceptance (Ahmad, Madarsha, Zainuddin, Ismail & Nordin, 2010; Chau, 1996) and useful in explaining technology adaption of software (Venkatesh & Davis, 2000). For example, this model has been employed and found useful in a region amongst 31 organisations in South Africa that assessed the contributions of variables explaining the implementation of Information Technology usage for decision-making in organizations (Averweg, 2008).

Context

In the study, described in this paper, "educational technology" is used to refer to the use of Dynamic geometry software (for example GeoGebra and Geometer's Sketchpad in mathematics) and PhET (in physics). Dynamic geometry software allows learners to discover patterns, to explore and to test conjectures by constructing their own sketches. Dynamic mathematics software can be a powerful teaching and learning medium and it has been reported by Sanders (1998) to (a) enhance mathematics teaching; (b) help with conceptual development; (c) enrich visualisation of geometry; (d) lay a foundation for analysis and deductive proof; and (e) create opportunities for creative thinking. Students can improve their understanding of geometry by using the software because the environment improves visualisation skills and ability to focus on interrelationships of the parts of geometric shapes (Clements, Sarama, Yelland & Glass, 2008). For example, dynamic geometry software allows students to drag any point on a sketch and because of this action a new measure of angles, line segments, and areas will be displayed. These tools could help learners to discover and explore algebraic and geometric relationships.

The physics simulations software, Physics Education Technology (PhET), was developed by a group of researchers from the University of Colorado at Boulder in the USA and is grounded in research on how students learn and their conceptual difficulties and misconceptions. The PhET project's goals are "increased student engagement, improved learning and improved beliefs about and approach toward learning" (Wieman, Perkins and Adams 2008, 394). The PhET simulations are highly interactive and provide animated feedback to the user. They are easy to use and are freely available at http://phet.colorado.edu/. The simulations model physically accurate, highly visual, dynamic representations of physics principles (Finkelstein, Adams, Keller, Kohl, Perkins, Podolefsky, Reid, & LeMaster, 2005). In developing the simulations, researchers made use of "student interviews and classroom testing to explore issues of usability, interpretation and learning" (Wieman, *et al.*, 2008, 394). For example when constructing an electric circuit, the student can click on the light bulb, battery, switch and connecting wires respectively and drag it to the interface. The correct connections have to be adhered to for the current to flow. This is indicated by a movement of the round circles in the connecting wires. They can also connect a volt- and ammeter to the circuit on which the readings are displayed.

Similarities and differences between the programs

The similarities between these programs are that both dynamic geometry software and PhET are free (open source) JAVA based software and underpins constructivist learning. The focus of both of the software is on interactivity and is to enhance learning and to promote thinking by exploring and conjecturing possible relationships. The software helps learners to visualise difficult situations and to test conjectures.

The difference between the programs are that the focus of dynamic geometry software is on the subject mathematics and that of PhET mostly science. Dynamic geometry software is software packages in which students have to construct their own sketches from scratch. All the menus,

with the drop down menus are available all the time which requires knowledge of the menus (where to find what).
The PhET simulations do not need explicit training. You can simply select a specific topic and only a few appropriate drag and drop menus are available to choose from. To use dynamic geometry software requires more technical knowledge about the software comparing to PhET simulations.

Research aim

The aim of this research was threefold. The first aim was to determine the influence of Grade 10 to 12 (16-18 years) mathematics and physical science teachers' beliefs about the usefulness and perceived ease of use on their attitudes towards the use of educational technology in their classroom. The second aim was to determine the impact of these teachers' attitudes, on their intention to use educational technology in their classrooms. Finally, their actual usage of the dynamic geometry software and PhET was compared with their intention to use it in their classrooms.

Research design

The exploratory study explored the relationships between beliefs about perceived usefulness and ease of use of educational technology and the attitude towards using it. However, the TAM model claim that there are a causal relationship between beliefs about the usefulness and the perceive ease of use and their attitudes towards the use of technology. Partial least squares analysis is a statistical technique that investigates a causal or influential relationship. This is a small scale exploratory study with a small sample size. This is why a structural equation modelling technique, in this case partial least squares analyses was used to analyse the data to explore a possible causal effect of beliefs on the attitude towards the use of technology. The small sample size imposed some limitations in terms of generalisability of results. By using partial least squares analysis, it was also possible to identify the effect weight of the attitude on the intention to use educational technology. Lastly, the intention was then compared with the actual usage by using descriptive statistics.

Workshop

Teachers must know and understand the advantages, limitations, functions and complexity of a software package to be able to form an opinion. The authors conducted a three-hour workshop one day a week for six consecutive weeks on the use of dynamic geometry software in the Mathematics classroom with the Mathematics teachers and use of PhET in the Physics classroom with the Physical Science teachers. The teachers then had to complete a questionnaire to investigate their beliefs about the use of dynamic geometry software and PhET respectively. The mathematics workshop covered geometric transformations (a new topic in the South African curriculum that is meant to use hands-on activities), transformations of graphs of functions, and Euclidian geometry. In essence, the workshop integrated the development of computer skills and mathematical discovery. In developing mathematics activities and materials, we followed the guidelines of (a) addressing mathematics with appropriate pedagogy; (b) taking advantage of technology; (c) connecting mathematics topics; and (d) incorporating multiple representations (Garofalo, Drier, Harper, Timmerman & Shockey, 2000).

The physics workshop focused on the Circuit Construction Kit (CCK) from the PhET project. The CCK addresses possible misconceptions about electric circuits; has visual representations of electron flow and allows users to vary the resistance and/or potential difference in order to encourage users to engage with concepts previously shown to be difficult (Finkelstein, *et al.*, 2005).

Participants and procedure

The study was carried out in South Africa, using a convenient sample of 46 teachers from 7 semi-urban and 12 urban schools. All schools were provided with computer laboratories. This sample consisted of 24 (10 male and 14 female) physical science teachers and 22 (12 male and 10 female) mathematics teachers, who represented a variety of cultures. All participants voluntary agreed to participate in this study and were teaching Grades 10 to 12. All teachers were familiar with the use of computers but have not applied/handled the software introduced in the study previously. Their average teaching experience was 15 years and their average age 42 years. Follow-up interviews were conducted with the teachers three months after the workshops.

Questionnaire

The first step in the design of the instrument was to elicit commonly held beliefs about the use of educational technology. A questionnaire consisting of 63 questions was designed by the authors using the guidelines set by Francis, Eccles, Johnston, Walker, Grimshaw, Foy, Kaner, Smith and Bonetti (2004). The following is an example of a question designed to determine the perceived usefulness of PhET: "The use of PhET will make it easier for the learners to visualise electric circuits". The equivalent question for the mathematics teachers was "The use of dynamic geometry software will make it easier for the learners to visualise the transformation of functions". A 7-point Likert scale was used for all the questions, varying from "extremely unlikely" to "extremely likely", or "definitely false" to "definitely true". There were 18 questions on beliefs about perceived usefulness and 18 questions on beliefs about perceived ease of use while 18 questions contributed to the attitudes and 9 to behaviour intention.

Results

Table 1 presents a summary of the responses in the mathematics questionnaire while Table 2 presents a summary of the responses to the physics questionnaire about the different categories and constructs of the TAM Model.

Table 1: Summary of the responses in the Mathematics questionnaire about the different constructs of the TAM model (7- point Likert scale was used.)

	n	Minimum	Maximum	Mean	Standard deviation
Behaviour intention	22	1.67	7.00	5.58	1.73
Attitude	22	5.00	7.00	6.51	0.66
Beliefs about Perceived ease of use	22	3.29	6.43	4.36	0.71
Beliefs about Perceived usefulness	22	4.86	7.00	6.32	0.61

n = number of teachers

Table 2: Summary of the responses in the Physical Science questionnaire about the different constructs of the TAM model (7- point Likert scale was used.)

	n	Minimum	Maximum	Mean	Standard deviation
Behaviour intention	24	1.00	7.00	5.55	1.62
Attitude	24	4.25	7.00	6.46	0.80
Beliefs about Perceived Ease of Use	24	3.14	5.60	4.33	0.79
Beliefs about Perceived Usefulness	24	4.50	7.00	6.24	0.70

The mean presented in Table 1 and Table 2 shows in general that the teachers had a positive attitude towards the use of technology and also intended to use it. For example, the mean for behaviour intention for using the mathematics software and the interactive simulations is respectively 5.58 and 5.55. The same trend is observable for attitude and it sub constructs, beliefs about perceive ease of use and perceived usefulness.

Influence of beliefs about PEU and PU on attitude (A)

Correlation statistics were used to explore the correlation between beliefs about the perceived ease of use (PEU) and perceived usefulness (PU) (see Table 3).

Table 3: The Pearson correlation coefficients between beliefs about Perceived Ease of Use (PEU), Perceived Usefulness (PU) and Attitude (A)

	Attitudes (Maths) n = 22	Attitudes (PhET) n = 24
Beliefs about Perceived Usefulness	0.89 (**)	0.83 (**)
Beliefs about Perceived Ease of Use	-0.14	0.08

** indicates a significance at the 0.01 level (two-tailed)

A highly significant correlation was found between the beliefs about perceived usefulness (PU) using dynamic geometry software and PhET in the classroom and the teachers' attitude. The beliefs about perceived ease of use (PEU) of dynamic geometry software as well as PhET had a negative and insignificant influence on both groups of teachers' attitude towards its use.

According to TAM, beliefs about perceived ease of use (PEU) and perceived usefulness (PU) will produce a positive or negative attitude towards the behaviour. Partial least squares analyses were used to explore this possible effect. With regards to mathematics, the model effect loadings for prediction of beliefs about PU and PEU on attitudes were 0.610 and -0.128 respectively, with weights of 0.664 and -0.086. For physics it was 0.81 and 0.07 respectively with weights 0.88 and 0.02. It can be concluded that only beliefs about perceived usefulness influenced both the Mathematics and Physical Science teachers' attitudes in this sample.

Influence of attitude on behaviour intention

A positive, statistically significant correlation was found between behaviour intention and attitude for Mathematics teachers but not for Physical Science teachers (see Table 4).

Table 4: Summary of the Pearson correlation coefficients between attitude and behaviour intention

	Behaviour intention (mathematics)	**Behaviour intention (physics)**
Attitude	0.55(*)	0.26

* indicate significance at the 0.05 level (two-tailed).

According to TAM, attitude towards the use of software will influence the intention to use the software. Partial least squares analyses were used to explore this possible effect. The partial least squares model effect loadings for mathematics were 0.45 with an effect weight of 0.46. The results suggest that Mathematics teachers' attitudes influence their behaviour intention to use dynamic geometry software. No statistically significant correlation was found between the behaviour intention of the Physical Science teachers and their attitude to use PhET.

Actual use in the classroom

According to TAM the actual usage of educational technology will be influenced by the behaviour intention. Therefore we compared the average score of the nine questions in the questionnaire that were posed to determine the behaviour intention and compared it with the teachers' actual use of educational technology in the classroom. Using the average score for these questions regarding behavioural intention, we regarded a score of higher than 4 on the 7-point Likert scale as a positive indication of their intention to use educational technology (see Table 5).

Three months after the workshop, we managed to contact 42 (91%) of the 46 teachers to verify if they had actually used educational technology in their classroom. Data from the questionnaires where they had to indicate their intention to use technology was compared with the actual usage (see Table 5).

Table 5: Behaviour intention (mean score out of 7) and actual use of technology (yes/no)

Mathematics (n =18)		*Actual use of dynamic geometry software*	
		Yes	*No*
Behaviour Intention	*Yes*	11 (6.72)	3 (6.57)
	No	-	4 (2.68)

Physics (n = 24)		*Actual use of PhET*	
		Yes	*No*
Behaviour Intention	*Yes*	14 (6.17)	5 (6.02)
	No	2 (1.50)	3 (2.53)

	Yes	No
Total (n= 42)	27	15

It revealed that a total of 33 of the 42 (78.6%) teachers intended to use educational technology in their classroom. These 33 teachers had an average score of more than 4 on the Likert scale for behaviour intention. However, of these 33 teachers that intended to use it 27 (81.8%) actually did use technology in their classrooms. Only 8 (19.0%) of the 42 teachers who had intended to use educational technology had not used it. Two teachers who indicated that they would not use it did in the end.

To investigate possible reasons why the teachers did not in the end use educational technology in their classrooms, the Physical Science teachers indicated that access to computers in their classroom was the only reason for not using PhET in the classroom. They did not want to go to the computer lab each time they started with a new topic in physical science. This suggests that there is a relationship between IT infrastructure and actual usage.

The mathematics teachers interviewed revealed that they did not use dynamic geometry software in their classroom because of their traditional teaching style. This emerged from their responses to the question: “Describe the most effective way to teach mathematics”. These teachers believed that the most effective way to teach mathematics is to “be patient, repeat, and drill”, “explain, explore, and give lots of exercises”, and “explain and drill”. The Physical Science who initially indicated that they did not intend using PhET but did subsequently use it in their classrooms indicated that their reasons were that when they had to teach “electric circuits” they decided to use PhET. One teacher indicated “it can be an effective tool when used to build circuits and measuring V and I because it becomes much easier when using PhET. Sometimes you don’t have batteries at school”. They used it whenever they started a new section because it helped the learners to visualise the concepts as was seen in the following “it gives a visual understanding of the concepts, theory becomes practical and understanding becomes much easier”. They also made effort to find a data projector from the school but used their own laptop in the classroom because “it benefits and African child and the love of science will be installed in learners – I will go the extra mile”.

Discussion

The first aim was to determine the influence of Grade 10 to 12 (16-18 years) Mathematics and Physical Science teachers’ perceived beliefs about the usefulness and perceived ease of use and their attitudes towards the use of educational technology in their classroom. This study found that only beliefs about perceived usefulness influenced their attitude towards the use of educational technology. A highly significant correlation was found between the beliefs about perceived usefulness (PU) using dynamic geometry software and PhET in the classroom and the teachers’ attitude with Pearson correlation coefficients of 0.89 and 0.83 respectively. Partial least squares were used to determine the reliability and for prediction of perceived usefulness. The model effect loading were 0.610 for Mathematics teachers and 0.81 for Physics Teachers’ use of technology respectively. However, the study found that the perceived ease of use had an insignificant influence on the attitude of the participants.

The second objective was to determine the impact of teachers’ attitudes, on their intention to use educational technology in their classrooms. This study could only partly confirm this relationship with a significant correlation between mathematics teachers’ attitudes and their intention with Pearson correlation coefficient of 0.55. The partial least squares model effect loadings for mathematics were 0.45 with an effect weight of 0.46.

Finally, these teachers actual usage of dynamic geometry software and PhET was compared with their intention to use it in their classrooms. This model predicted the actual usage of educational technology in the classroom with 78.6% accuracy. The mathematics teachers that did not use dynamic geometry software in their classroom all indicated in the interviews that they have a traditional teaching style unlike those of the other teachers who did use dynamic geometry software. The use of dynamic geometry software, in general, promotes a more constructivist approach. This suggests that a relationship exists between pedagogical beliefs of the teachers and their use of educational technology. These findings resonates well with Ertmer’s (2005, 26) statement: “If we truly hope to increase teachers’ uses of technology, especially uses that increase student learning, we must consider how teachers’ current classroom practices are rooted in, and mediated by, existing pedagogical beliefs”. We can therefore conclude that the teaching style of the mathematics teachers who intended to use dynamic geometry software but did not use it was not compatible with a style needed for proper use of it.

Conclusion

Technology can be used to strengthen student learning, but it is not commonly used in mathematics and physical science classrooms in South Africa. In order to implement educational technology in teaching and learning we need a better understanding of the beliefs that influence teachers’ use of technology. The TAM model is a tool for testing user acceptance of new technologies and proposes that people’s beliefs about perceived usefulness and perceived ease of use have an effect on their attitude towards the use which influences their behaviour intention and can be correlated with their actual behaviour. TAM suggests that beliefs about perceived usefulness and perceived ease of use have an effect on their attitude towards the use which influences their behaviour intention and can be correlated with their actual behaviour. A highly significant correlation between the beliefs about perceived usefulness (PU) using either dynamic geometry software or PhET and attitude was found in spite of the difference between these two technologies. Dynamic geometry software requires knowledge of the menus and training to use it effectively while PhET use simple customised menus (depending on the topic) and does not requires training.

These preliminary findings will be able to focus the attention of district officials that they need to consider teachers beliefs if they want teachers to use educational technology in their classrooms. In order to promote the use of it, when designing professional development programmes teachers must be exposed to the technology to experience its usefulness in mathematics and science teaching. Technology needs to be used to strengthen student learning. However, to equip all schools in South Africa could be costly and ways need to be found to determine if technology would be used. TAM that was adapted as theoretical framework for this study can be regarded as a primary tool for testing user acceptance of new technologies and can be used with success in the South African school context.

Limitations and further research

This was an exploratory study with a limited number of participants which was used to predict actual usage of educational technology in the classroom. A follow up study needs to be considered with more participants, greater variety of technologies and possibly include subject areas like life science and chemistry.

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