EXTENDING THE TECHNOLOGY ACCEPTANCE MODEL TO ASSESS SECONDARY SCHOOL TEACHERS’ INTENTION TO USE CABRI IN GEOMETRY TEACHING

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The purpose of this study was to modify and extend Technology Acceptance Model to assess secondary school teachers’ intention to use Cabri in geometry teaching. We developed a measurement-structural model and enriched TAM by integrating in the model a new significant parameter, “perceived pedagogical-learning fit”, which refers to evaluating the pedagogical-learning appropriateness of teaching geometry with Cabri based on a cognitive-learning model. One hundred and five pre and in-service secondary school mathematics teachers answered a questionnaire that was developed based on related research studies. The results of the study proved that perceived pedagogical-learning fit and attitude towards the use of Cabri are key determinants of teachers’ behavioural intention to use Cabri in geometry teaching.

INTRODUCTION

The technology acceptance model (TAM) is well known and widely accepted in the study of specific behaviours to understand how users’ beliefs and attitudes affect their technology usage behaviour (Teo, Lee, Chai & Wong, 2009; Venkatesh & Davis, 2000). TAM has been used widely in different domains and cultures to test models in technology acceptance (Dishaw & String, 1999; Lee, Yoon & Lee, 2009) and has received extensive empirical support. TAM applications are mostly related in the outcome chain on intention to use or actual use by taking into consideration as fundamental determinants of user acceptance the variables perceived usefulness and perceived ease of use (Davis, 1989). Having in mind the business and commercial origins of TAM, not surprisingly, it has had limited applications in education. Recent research studies of TAM in education have explored students’ or teachers’ acceptance towards new technologies such as online learning, and technology in education (Lee, Yoon, & Lee, 2009; Stols, 2007).

Dishaw and Strong (1999) support that a weakness of TAM is its lack of task focus and extended the model to integrate task-technology fit (TTF), which refers to matching the capabilities of the technology to the demands of the task. In the present study, we integrate TAM and TTF theoretical considerations to extend and propose a structural and measurement technology acceptance model that assesses the intention of pre and in-service secondary school teachers to use Cabri, dynamic geometry software, in geometry teaching. To evaluate the intention of use of Cabri based on a theoretical geometry learning model, we modified TAM by adding in the model teachers’ perceived learning fit of Cabri on a task-technology fit theoretical assumption.
THEORETICAL CONSIDERATIONS

Technology Acceptance Model

TAM is based on the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and explains how users’ beliefs and attitudes affect their intention to use a specific technological device. TAM explains the interactions among attitudes, beliefs and intention to use technology. The two belief variables refer to perceived usefulness and perceived ease of use (Teo et al., 2009). Perceived usefulness refers to the subjective belief that the use of new technology will improve job performance and productivity. Perceived ease of use refers to the subjective belief that the use of the new technology does not demand considerable time and effort. Recent studies have shown that the above variables affect users’ intention to use and their attitude towards technology use (Cheung & Huang, 2002; Raaij & Schepers, 2008). Attitude has been doubtfully hypothesized to influence the behavioural intention to use the technology and was therefore not considered in later assessments of the model (Venkatesh & Davis, 2000).

Although TAM’s perceived usefulness concept implicitly includes task, the model has been criticized for the lack of task focus and its application revealed mixed results in information technology evaluations (Dishaw & Strong, 1999). In contrast to TAM, the theoretical foundation of the task-technology fit model (TTF) lies in the assumption that technology will be used if, and only if, the functions available to the user fit the activities and needs of the user. Thus, TTF explicitly includes task characteristics and tests for direct effects of task and technology characteristics on utilisation.

Mathematics Teachers’ views about using DGS

Dynamic geometry software (DGS) has been considered as an effective tool in the teaching and learning of geometry and proved to have the potential to regenerate geometry in schools (Hollebrands, Laborde, & Straesser, 2008). DGS have become beneficial tools in geometry teaching, because they support students’ visualization of the features of geometric shapes and facilitate the interaction of geometrical objects (Healy & Hoyles, 2001). However, research studies have shown that DGS classroom use has remained limited (Ofsted, 2004). Researchers noted that a significant parameter of the problem is the absence of teachers’ contribution (Lagrange, 2008). Jones (2002) asserted that, in the DGS field, there is a need for research on teachers’ input and impact. Therefore, the success of a DGS geometry teaching program depends on the extent to which educational decision makers take into consideration teachers’ needs and beliefs and educational objectives. Thus, the development of an appropriate DGS teaching program is a complicated task and requires a multidisciplinary approach. Teachers’ evaluation of the DGS and their beliefs and attitude towards the DGS should be a fundamental pillar of the initiative.

Cabri is one of the dominant software in the domain of dynamic geometry for dynamically creating, exploring, elaborating, analysing and synthesizing geometrical concepts (Laborde, 2001; Laborde & Laborde, 2008). It could facilitate the process of
discovering geometrical concepts by first visualizing, analyzing and then making conjectures. Several research studies have shown that geometry teaching and learning in Cabri could promote and enhance students’ visualization, reasoning and construction processes (Olivero, & Robutti, 2007).

Despite the potential of Cabri as a tool to enhance students’ geometric thinking and improve their geometry performance, its value will not be realized if teachers do not accept it as an effective learning tool. TAM has been utilized and extended for research purposes in education to assess pre or in service teachers’ acceptance of other information technology innovations, such as e-learning (Lee et al., 2009) and virtual-learning (Raaij & Schepers, 2008). Results showed that perceived usefulness and perceived ease of use proved to be critical parameters of the acceptance and usage of the innovation as an effective and efficient learning technology.

THE PRESENT STUDY

There is a research need to establish an empirical link between TAM and specific mathematics geometry software. Thus, the main purpose of the study is to extend TAM and propose a structural and measurement technology acceptance model that could be used to evaluate the intention of teachers to use Cabri in geometry teaching. The present study adds to the research literature on TAM and DGS in a number of ways. First, it integrates TAM and TTF theoretical considerations by proposing a model that evaluates the task-technology fit of Cabri based on teachers’ perceived pedagogical-learning fit of the software. By the term “perceived pedagogical-learning fit” we refer to teachers’ perception about the quality of teaching and learning of geometry with Cabri and whether the specific software could meet the learning needs of students in geometry. To do so, the study proposes a model that evaluates Cabri’s perceived pedagogical-learning fit based on Duval’s cognitive geometry reasoning model (Duval, 1998). Second, the study may provide a worthwhile starting point in mathematics educational technology field in developing appropriate evaluation models that could be used to evaluate the pedagogical value of DGS.

Aims of the study and the proposed model

The purpose of the present study is to propose a model that extends TAM to assess teachers’ intention to use Cabri in geometry teaching based on teachers’ perceived pedagogical fit of the software. Specifically, the aims of the study were to (a) to validate the measurement model that describes teachers’ perceived pedagogical fit of Cabri based on Duval’s geometry reasoning model and (b) to extend and modify TAM so it could potentially be used to assess, on a task-technology fit basis, the intention to use Cabri by integrating in the model, as a task-technology fit parameter, the effect of teachers’ perceived pedagogical fit.

In this paper, as it is highlighted in Figure 1, we hypothesized that an additional parameter, “perceived pedagogical-learning fit”, influences teachers’ intention to use Cabri in geometry teaching. Specifically, based on the literature we assumed that a
theoretical construct “perceived pedagogical-learning fit” describes teachers’ perceived pedagogical and learning appropriateness of geometry teaching with Cabri to develop students’ visualisation, reasoning and construction processes. Based on Duval’s model (1998), geometrical reasoning involves three kinds of cognitive processes which fulfil specific cognitive processes; (a) visualization processes that refer to the visual representation of a geometrical concept, (b) construction processes that can be developed in Cabri by appropriate tools and (c) reasoning processes that are necessary for the extension of knowledge, for explanation and proof. Thus, the latent construct “perceived pedagogical-learning fit” consists of three first-order latent factors that refer to teachers’ perceived visualization, construction and reasoning processes fit of teaching with Cabri. In addition, based on TAM theory (Dishaw & Strong, 1999), we hypothesized that teachers’ intention to use Cabri in geometry teaching is influenced by teachers’ (a) perceived usefulness of Cabri and (b) their attitude towards the use of Cabri. Perceived usefulness was also hypothesized to be influenced by perceived ease of use and attitude towards the use of Cabri was assumed to be predicted by the factors perceived ease of use and perceived usefulness.

![The hypothesized model](image)

**Figure 1: The hypothesized model.**

**Subjects**

The sample of this study consisted of 105 pre and in-service secondary school mathematics teachers. More specifically, the sample consisted of 45 pre-service and 60 in-service teachers. Forty two teachers were males and 63 females. All the subjects attended a compulsory 9-hours module regarding Cabri and its pedagogical applications during their teacher training program in the University of Cyprus during spring 2010. The questionnaire was administered after the completion of the Cabri module. None of the subjects had previous experience with Cabri.
Instrument construction

A questionnaire instrument was developed for this study. TAM scale items were adopted from previous studies (Dishaw & Strong, 1999; Lee et al., 2009; Teo et al., 2009) and were modified to meet the needs of the present study. Our research TAM model consists of 12 items (see Table 1) that measured “perceived ease of use” (3 items), “perceived usefulness” (3 items), “attitude towards use of Cabri” (3 items) and “use intention” (3 items). In addition, based on the existing literature on geometry reasoning discussed in the previous sections, we developed 10 items that measured teachers’ perceived pedagogical-learning fit. For example (see Table 2), the item “Teaching geometry with Cabri helps in visualizing geometrical concepts” was used to measure “visualization processes” fit, the item “Cabri’s measurement and dragging tools help students making generalisations” was used to examine the “reasoning processes” fit and the item “Cabri’s tools make easy the construction of complex geometrical constructions, such as locus” was developed to examine the “construction processes” fit. We developed multi-item Likert scales which have been widely used in the questionnaire-based perception studies, using the seven-point Likert scale, with 7 being “Totally Agree” and 1 being “Totally Disagree”.

Table 1: TAM items.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Items</th>
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<tr>
<td>Perceived usefulness</td>
<td>Q1. Using Cabri in geometry teaching will enable me to accomplish my tasks more quickly.</td>
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<td></td>
<td>Q2. Using Cabri in geometry teaching will enable me to enhance my effectiveness in teaching.</td>
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<td></td>
<td>Q3. Using Cabri in geometry teaching will enable me to increase my productivity in teaching.</td>
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<td>Perceived ease of use</td>
<td>Q4. My interaction with Cabri tools will be clear and understandable.</td>
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<td></td>
<td>Q5. I will find the Cabri tools to be flexible to interact with.</td>
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<tr>
<td></td>
<td>Q6. I will find the Cabri tools easy to use.</td>
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<tr>
<td>Attitude towards Use</td>
<td>Q7. I think it would be very good to use Cabri in geometry teaching rather than traditional methods.</td>
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<tr>
<td></td>
<td>Q8. In my opinion it would be very desirable to use Cabri in geometry teaching rather than traditional methods.</td>
</tr>
<tr>
<td></td>
<td>Q9. Teaching geometry with Cabri makes the lesson more interesting.</td>
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<tr>
<td>Use intention</td>
<td>Q10. I will use Cabri in geometry teaching rather than traditional methods of teaching geometry.</td>
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<td></td>
<td>Q11. My intention is to use Cabri in geometry teaching rather than traditional teaching methods.</td>
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<tr>
<td></td>
<td>Q12. In geometry teaching, I would rather use Cabri than traditional teaching methods.</td>
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**Data Analysis**

The goal of the analysis was to estimate the relative strength of the proposed models. Because we proposed a theoretically driven model about the components of “perceived pedagogical-learning fit”, our first interest was in the assessment of fit of the hypothesized a priori measurement model to the data. Then, we examined the validity of the hypothesized structural model. One of the most widely used structural equation modelling computer programs, MPLUS, was used to test for model fitting (Muthen & Muthen, 2007) and three fit indices were computed: The chi-square to its degrees of freedom ratio ($\chi^2/df$), the comparative fit index (CFI), and the root mean-square error of approximation (RMSEA). The observed values for $\chi^2/df$ should be less than 2, the values for CFI should be higher than .9, and the RMSEA values should be lower than .08 to support model fit (Marcoulides & Schumacker, 1996).

**Table 2: Perceived Pedagogical-Learning Fit items.**

<table>
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<tr>
<th>Factor processes</th>
<th>Items</th>
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<tr>
<td>Visualization</td>
<td>Q13. Teaching geometry with Cabri helps in visualizing geometrical concepts.</td>
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<td></td>
<td>Q14. Cabri facilitates the dynamic visualization and understanding of geometric theorems.</td>
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<td></td>
<td>Q15. Cabri’s functions (i.e. dragging) help students to “see” the properties and characteristics of geometric shapes.</td>
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<td></td>
<td>Q16. Cabri offers dynamic images that promote dynamic visualisation of geometrical concepts.</td>
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<tr>
<td>Reasoning processes</td>
<td>Q17. Teaching geometry with Cabri helps in developing students’ reasoning and conjecturing thinking.</td>
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<td></td>
<td>Q18. Manipulating shapes in Cabri contributes in understanding geometric shapes’ relations.</td>
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<td></td>
<td>Q19. Cabri’s measurement and dragging tools help students making generalisations.</td>
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<tr>
<td>Construction processes</td>
<td>Q20. Cabri’s tools make possible the construction of geometric shapes based on their properties.</td>
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<td></td>
<td>Q21. Cabri’s tools make easy the construction of complex geometrical constructions, such as locus.</td>
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<td></td>
<td>Q22. Constructing geometric shapes in Cabri is not a mechanical process, but it develops students’ construction abilities.</td>
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**RESULTS**

In this section, we refer to the results of the analysis, establishing the validity of the latent factors and the viability of the structure of the hypothesized latent factors. In this
study, we posited an a-priori measurement model and tested the ability of a solution based on this structure to fit the data and then conducted a structural analysis to examine the relation between the factors of the modified TAM.

To examine the first aim of the study, we conducted a confirmatory factor analysis (CFA) to validate a measurement which should have been able to model teachers’ perceived pedagogical-learning fit of Cabri. The descriptive-fit measures indicated support for the hypothesized measurement model ($\text{CFI}=.94$, $\chi^2/df=1.32$, $p>0.05$, $\text{RMSEA}=.06$). The parameter estimates were reasonable in that all factor loadings were statistically significant and most of them were rather large. The analysis showed that each of the 10 perceived learning fit items employed in the present study loaded adequately only on one of the three geometry processes fit factors, giving support to the assumption that the three first-order factors could represent three distinct dimensions of teachers’ perceived learning fit. Moreover, the factor loadings of the first-order factors (visualization, reasoning, and construction processes learning fit) that corresponded to teachers’ perceived pedagogical-learning fit were extremely high (.90, .99 and .99 respectively), claiming that a general type of belief that refers to teachers’ perceived pedagogical-learning fit could explain very accurately teachers’ variances in evaluating Cabri.

To examine the second aim of the study, we tested the validity of the hypothesized structural model, which claimed that the intention to use Cabri is influenced by the factors “perceived usefulness”, “attitude towards use of Cabri” and “perceived learning fit”. The descriptive-fit measures did not support the hypothesized structural model ($\text{CFI}=.86$, $\chi^2/df=1.56$, $p<0.05$, $\text{RMSEA}=.09$). Thus, we examined the validity of alternative structural models to trace the relations between the factors of the model. Figure 2 presents the modified model that best fitted the empirical data ($\text{CFI}=.92$, $\chi^2/df=1.34$, $p<0.05$, $\text{RMSEA}=.07$). As it is highlighted in Figure 2, the results of the study revealed that the factor “perceived pedagogical-learning fit” is a strong predictive factor of teachers’ intention to use Cabri ($r=.69$, $z=4.02$, $p<0.05$). In addition, teachers’ perceived pedagogical-learning fit predicts (a) teachers’ attitude towards the use of Cabri ($r=.66$, $z=3.44$, $p<0.05$), (b) teachers’ perceived ease of use ($r=.56$, $z=3.09$, $p<0.05$) and (c) teachers’ perceived usefulness ($r=.96$, $z=4.02$, $p<0.05$). It could be concluded that teachers’ perceived usefulness is strongly affected by their perceived pedagogical-learning fit. The structure of the modified model showed that attitude towards the use of Cabri is also predicted by teachers’ perceived ease of use ($r=.47$, $z=3.71$, $p<0.05$) and attitude towards the use affects directly teachers’ intention to use Cabri ($r=.36$, $z=1.97$, $p<0.05$). Further, the solution of the modified model did not validate the direct effect of the factor “perceived usefulness” on other variables. On the contrary, it was deduced that teachers’ perceived usefulness does not influence neither their attitude towards the use of Cabri, nor their intention to use it.
DISCUSSION

This study attempts to modify and extend TAM by integrating in the model a new significant parameter, “perceived pedagogical-learning fit”, which refers to assessing the pedagogical-learning appropriateness of teaching geometry with Cabri based on a cognitive-learning model. In examining the relations among the constructs in the modified TAM, this study found that perceived pedagogical-learning fit and attitude towards the use of Cabri were key determinants of teachers’ behavioural intention to
use Cabri in geometry teaching. Attitude towards the software proved also to be significant predictor in other research studies that examined users’ intention to use computers in education (Teo et al., 2009; Venkatech, Morris, Davis & Davis, 2003).

It is important to note that adopting non-educational derived behavioural intention models to assess teachers’ intention to use software in teaching might give misleading information. Our results yielded that an important parameter that should be examined is teachers’ perceived evaluation of the pedagogical learning fit of the software. The results of this study suggest that teachers’ perceived ease of use, their attitude towards the use and especially their perceived usefulness are significantly influenced by their pedagogical-learning evaluation of the software. For teachers what matters to use the software is the additive, learning value of the software. Thus, although for the past two decades, numerous studies using the TAM as a research framework have been conducted, there is a need for future research in math education domain that modifies TAM according to the learning needs that the innovative technology/software should meet, based on well established learning and cognitive models.

REFERENCES


