TEACHERS' BELIEFS ABOUT THE ADOPTION OF NEW TECHNOLOGIES IN THE MATHEMATICS CURRICULUM

Marilena Chrysostomou & Nicholas Mousoulides

Department of Education, University of Cyprus

The purpose of the present study was to examine elementary mathematics teachers' concerns in relation to the expected implementation of the new technology based mathematics curriculum in Cyprus. A questionnaire examining teachers' concerns towards this innovation was administered to seventy four elementary school teachers. Results provide evidence that the majority of teachers were positive towards the innovation. Results revealed the existence of four factors related to teachers' concerns and beliefs towards the innovation, namely the concerns about the nature of the curriculum, teachers' self-efficacy beliefs, concerns about the consequences on the organization of teaching, and concerns about the effectiveness of the curriculum.

INTRODUCTION AND THEORETICAL FRAMEWORK

Based on the premise that Information and Communication Technologies (ICT) can have a positive impact on mathematics teaching and students' learning outcomes, technology based activities have been implemented in mathematics curricula in a number of countries (Hennessy, Ruthven, & Brindley, 2005). This implementation is, however, not an easy yet straightforward task; a number of factors such as mathematics teachers' beliefs and concerns about the adoption of this innovation, facilities, in-service teachers' training, and available resources might influence the successful implementation of the innovation (Hennessy, et al., 2005).

Gibson (2001) argues that technology by itself will not and can not change schools. It is only when reflective and flexible educators integrate technology into effective learning environments, that the restructuring of the classroom practices will benefit all learners. The introduction and implementation of ICT in the teaching and learning of mathematics has not been successful in a number of cases in different countries (Hennessy, et al., 2005). As reported by the British Educational Communications and Technology Agency (2004), only few teachers succeed in integrating ICT into subject teaching in a fruitful and constructive way that can promote students' conceptual understandings and can stimulate higher-level thinking and reasoning. In most of the cases, teachers just use technology to do what they have always done, although in fact they often claim to have changed their teaching practice. Further, a number of teachers report that they do not feel comfortable with the integration of ICT in subject teaching, since their role was predetermined and designed by educational authorities and teachers feel that they face a lack of professional autonomy (Olson, 2000). Olson (2000) proposes that integrating new technologies challenges teachers and, thus,

requires innovators to understand and be engaged "in conversations with teachers about their work culture, the technologies that sustain it and the implications of new approaches for those technologies" (p.6).

Among the factors that have been identified as crucial for the successful integration of ICT in the mathematics curricula are teachers' concerns and beliefs about this change (Van den Berg et al., 2000). To this end, a number of studies focused their research efforts on examining teachers' concerns towards the adoption of ICT in general (Gibson, 2001) or towards an innovation in education (Hall & Hord, 2001). According to Hord and colleagues (1998), concerns can be described as the feelings, thoughts, and reactions individuals develop in regard to an innovation that is relevant to their job (Hord, Rutherford, Huling-Austin & Hall, 1998). In this framework, innovation concerns refer to a state of mental arousal resulting from the need to cope with new conditions in one's work environment (Hord et al., 1998). Furthermore it is argued that teachers are also important as representatives of their students' needs. In this respect, the opinions and views of teachers can be considered to be reflective of opinions and views from two major stakeholder groups instead of one, and this further underlines the importance of studying teachers' concerns before and during implementing a new innovation in education (Hossain, 2000).

A model that has been widely used for the evaluation of the innovations in education is the Concerns-Based Adoption Model (CBAM) (Hord, et. al., 1998). This model can be used to identify how, for example, teachers (who feel that they will be affected by the new technology based curriculum in mathematics) will react to the implementation of the innovation (Christou et al., 2004). The CBAM includes three tools that are used for collecting data related to teachers' concerns and beliefs. These tools include: (a) the levels of use questionnaire, (b) the innovation configurations, and (c) the stages of concerns questionnaire. The stages of concerns questionnaire was adopted, modified and used in the present study to measure elementary school teachers concerns and beliefs about the innovation of introducing a technology based mathematics curriculum (Hall & Hord, 2001). The stages of concerns questionnaire includes items for measuring teachers' concerns towards seven stages of concern, namely the Awareness, Informational, Personal, Management, Consequences, Collaboration, and Refocusing stages.

Briefly, in the awareness stage teachers have little knowledge of the innovation and have no interest in taking any action. In the informational stage teachers express concerns regarding the nature of the innovation and the requirements for its implementation. In the personal stage teachers focus on the impact the innovation will have on them, while in the management stage their concerns begin to concentrate on methods for managing the innovation. In the consequences and collaboration stages their concerns focus on student learning and on their collaboration with their colleagues. Finally on the refocusing stage teachers evaluate the innovation and make suggestions for improvements related to the innovation and its implementation (Hord et al., 1998).

PURPOSE AND RESEARCH QUESTIONS

The purpose of the present study was to examine teachers' beliefs about an innovation that will soon take place in Cyprus, namely the adoption of a new mathematics curriculum. The new curriculum is expected to incorporate an inquire based approach and to integrate technological tools into the teaching and learning of mathematics. The study aimed at investigating how well prepared teachers feel about implementing the new curriculum and whether teachers are positive towards this innovation.

The research questions of the study were the following:

(a) What beliefs do teachers have regarding the adoption of a mathematics curriculum that integrates technology?

(b) Do teachers' beliefs differentiate in accordance to their teaching experience and their studies?

(c) Do teachers feel capable to implement the new curriculum and if not, what do they reported that they need to be appropriately prepared?

METHODOLOGY

Participants

The participants in this study were 74 teachers from nine elementary schools in Cyprus. Schools were randomly selected from the district of Nicosia. One hundred questionnaires were mailed to schools and 74 were returned to researchers. Teachers were grouped according to their teaching experience and their studies, in three categories and in two categories, respectively. The numbers of teachers in each group are presented in Table 1.

Table1. *Teachers involved in the study by years of teaching experience and level of studies*

Studies	Teaching experience		
	1-5	6-15	>15
Postgraduate studies	16	13	9
Undergraduate studies	6	16	14
Total	22	29	23

Batteries

The questionnaire included 23 likert-scale items. Part of the items was adopted from previous stages of concerns questionnaires (e.g., Hall & Hord, 2001; Christou et al., 2004). Since these studies focused on teachers' adoption of innovations in general, the items were modified to serve the purposes of investigating teachers' concerns of the adoption of the innovation of using ICT in the teaching of mathematics. The 23 items were on a 7-point likert scale, from 1 (strongly disagree) to 7 (strongly agree); all responses were recorded so that higher numbers indicated greater agreement with the statement. The questionnaire also included two open-ended questions in which teachers were asked to report on: (a) what they need in order to feel confident and well prepared to implement the new technology-based mathematics curriculum, and (b) their beliefs and concerns in general about their new role in teaching mathematics after the implementation of the innovation.

The data were analyzed using the statistical package SPSS. An exploratory factor analysis and an multiple analysis of variance were conducted. Descriptive statistics were also used.

RESULTS

The exploratory factor analysis resulted in four factors, including the 21 items of the teachers' questionnaire. The following four factors arose: (a) Concerns/Beliefs about the nature of the new mathematics curriculum, (b) Teachers' self-efficacy beliefs, (c) Concerns about the consequences on the organization of teaching, and (d) Concerns/Beliefs about the effectiveness of the new curriculum. The loadings of each statement in the four factors are presented in Table 2.

Furthermore, teachers that participated in the study appeared to have positive beliefs about the nature of the proposed new curriculum ($\bar{x}$=5,1). Particularly, the majority of teachers reported that the new curriculum will put emphasis on pupils' way of thinking and their reasoning skills, on problem solving and on the enhancement of students' conceptual understanding. The mean score of the 'Self-efficacy beliefs' factor ($\bar{x}$=4,1) might claim that teachers feel quite confident and well prepared to use the new curriculum. Although the mean score can be considered quite large, it is important to underline that the majority of teachers reported that there is a strong need for in-service teachers' training before the implementation of the innovation.

Furthermore, it seems that teachers' beliefs concerning the consequences on the organization of teaching are also rather positive. The mean score ($\bar{x}$=4,0) reveals that many teachers who participated in this study believe that after the implementation of the curriculum the stress of the teacher regarding the organization of teaching will be reduced and that this innovation will relieve the teacher from a great deal of

Table 2: *Factor analysis results*

	Factors			
Statements	F1	F2	F3	F4
The adoption of the new curriculum will place sufficient emphasis on the development of pupils' thinking.	,831			
The use of the computer in mathematics develops pupils' mathematical thinking and reasoning skills.	,744			
The new curriculum that takes advantage of the computer in the teaching of mathematics promotes problem solving.	,730			
The use of computers promotes conceptual understanding in mathematics.	,704			
The new curriculum places emphasis on investigation.	,618			
The knowledge that students acquire through the use of computers is not superficial.	,572			
I do not feel confident about teaching mathematics with computers.		,808		
I do not face difficulties in teaching mathematics with computers.		,759		
The implementation of the new curriculum requires the use of methods that I am not familiar with. (recoded)		,723		
I do not need guidance to teach mathematics with the use of computers. (recoded)		,715		
I know how to use computers effectively in mathematics in the classes that I teach.		,541		
The computer based activities that will be included in the new curriculum will reduce teacher's preparation.			,856	
With the implementation of the new curriculum, teachers' stress about the organization of teaching will be reduced.			,846	
Pupils' homework will be reduced.			,578	
Teaching of mathematics with the use of computers will allow me to follow the progress of each pupil.				,775
The adoption of the new curriculum is a useful innovation.				,613
I believe that the adoption of the new curriculum will improve students' achievement.				,557
The integration of computers in mathematics teaching will result in major changes in the teaching of mathematics.				,418

preparation. They also reported that they expect that pupils' homework will be reduced and that the integration of technology will improve the organization/management of the classroom.

Similarly, the mean score for the forth factor was also quite large ($\bar{x}$=5,3). Teachers appeared to be positive that the new curriculum will introduce major changes in the teaching of mathematics and that it will improve results. They also consider the mathematics curriculum that integrates technology as a useful innovation in primary education mathematics and as a means that will allow them to follow the progress of each pupil.

Table 3: *The four factor model mean scores*

Factors	Mean	SD
F1: Beliefs about the nature of the new mathematics curriculum	5,1	0,9
F2: Teachers' self-efficacy beliefs	4,1	1,2
F3: Concerns/Beliefs about the consequences on the organization of teaching	4,0	1,2
F4: Concerns/Beliefs about the effectiveness of the new curriculum	5,3	0,9

In order to investigate whether teachers' beliefs in four factors differentiate in accordance to the years of teaching experience and level of studies, a multivariate analysis of variance (MANOVA) was conducted, with the statements of teachers in four factors as dependent variables and years of teaching experience and studies as independent ones. The results of the multivariate analysis showed that there were significant differences between teachers beliefs across the years of teaching experience (Pillai's $\underline{F}_{(2,64)}$ = 2,211, p<0,05). More concretely, the results indicated that there were statistically significant differences between the three groups only in the first factor, 'Beliefs about the nature of the new mathematics curriculum' (F=5,667, p<0.05). It was found that the significant differences related to this factor appeared only between inexperienced teachers (years of teaching experience: 1-5) and experienced teachers (6-15) (p<0.05) and between inexperienced teachers and teachers with more than 16 years of experience who probably possess administrative places (16+) (p<0.05). As the years of experience increase the beliefs about the nature of the curriculum get higher. In the other three factors there were no significant differences between the three groups of teachers. The results of the multivariate

analysis indicate that there were no significant differences between teachers' beliefs in the four factors in relation to their level of studies (Pillai's $\underline{F}_{(1,68)} = 0{,}661$, $p > 0{,}05$).

Of importance are also teachers' responses to a number of individual items of the questionnaire. The item with the highest mean score ($\bar{x}=6{,}1$) was the one that referred to the need for training courses. Specifically, the majority of teachers (60 teachers), agreed strongly (chose 7) or very much (chose 6), and only two teachers disagreed that training courses are necessary for the successful implementation of the technology based curriculum in mathematics. The items with the lowest mean score were the 'The knowledge that students acquire through the use of computers is superficial' ($\bar{x}=2{,}7$) and 'The adoption of the new curriculum for the integration of computers in the teaching of mathematics is a useless innovation' ($\bar{x}=2{,}1$). Teachers' responses to these items also showed that teachers consider the integration of technology in the teaching of mathematics as a useful innovation that will enforce learning, something that is in line with the high mean score ($\bar{x}=5{,}2$) which refers to the improvement of students' achievement after the implementation of the new curriculum. Their positive beliefs and willingness to integrate technology into teaching appears also from the high mean score ($\bar{x}=5{,}2$) of the item 'I would like to teach mathematics lessons using computers'.

Table 4: *Mean scores for questionnaire items*

Items	Mean	SD
The knowledge that students acquire through the use of computers is superficial.	2,7	1,2
Training courses for the integration of computers in the teaching of mathematics are necessary for teachers.	6,1	1,3
I would like to observe and participate in technology based mathematics lessons taught by more experienced teachers.	5,2	1,4
I believe that the adoption of the new mathematics curriculum that integrates technology into teaching will improve students' achievement.	5,2	1,1
The adoption of the new curriculum for the integration of computers in the teaching of mathematics is a useless innovation.	2,1	1,7

Teachers' need for training courses came also up from their answers in the first open-ended question. Fifty-five teachers answered this question and some of the answers consisted of a combination of different ideas. For this reason some of the teachers are included in the percentage of more than one category of answers. Forty-six teachers (83,6%) stated that they need 'Training courses for the integration of computers in the teaching of mathematics'. The second category that was pointed out by ten teachers (18%) was 'lesson plans and worksheets'. Also, ten teachers (18%) expressed that it is essential to become familiar with the software that will be used, before implementing the innovation, and eight teachers revealed their wish to attend courses that will be held by more experienced teachers. Six teachers stated that they need much guidance, three that they considered the co-operation with colleagues important and three that they need the appropriate infrastructure. The last four answers that were reported only by one teacher each, are the following: (a) training courses for the use of computers, (b) more hours devoted to the teaching of mathematics, (c) one coordinator in each school, and (d) adaptation of the books according to the purpose of the curriculum that integrates technology into teaching.

Regarding the second open-ended question, five categories of answers were identified from the 53 answers that were gathered. The majority of teachers (46 teachers-88.7%) stated that they feel that their role would be more like a facilitator during the learning process. Three teachers reported that their role will remain the same and two just mentioned that they will have a decisive role. Lastly, one teacher pointed out that his role will change; he will need to first develop more positive attitudes and knowledge towards the innovation and then transfer them to his students.

DISCUSSION

The purpose of this study was to examine teachers' beliefs and concerns regarding the expected innovation of integrating the new technology-based curriculum in mathematics at the elementary schools in Cyprus.

The questionnaire was used to provide a description of teachers' concerns and beliefs about the integration of the new technology-based mathematics curriculum, which shows that the great majority of teachers welcome the expected change in mathematics curriculum after the introduction of ICT and they seem to have positive beliefs in general and positive self-efficacy beliefs for teaching mathematics using ICT (Chamblee & Slough, 2002).

The present study showed that in general teachers welcome the introduction of ICT in mathematics education. According to the teachers that participated in the study, however, the majority underlined the importance of in-service and pre-service training on implementing ICT in the mathematics teaching. This is crucial for the successful implementation of the innovation as, according to teachers' answers, teacher role will be changed, new classroom dynamics will appear, and student learning in mathematics will be improved. The results of the study also revealed that

teachers believe that this innovation is important and can positively change the way mathematics are taught and student learning can be improved, but this is not an easy task; careful planning is needed and resources like software and lesson plans will help teachers in their new different role (Luehmann, 2002).

The results revealed that differences of beliefs across different groups of teachers in terms of teaching experience existed only for the first factor, namely the 'Beliefs about the nature of the new mathematics curriculum'. Specifically, teachers' beliefs about the nature of the curriculum differed between the inexperienced teachers and teachers with more than five years of experience. As teachers' experience increases, teachers feel that the new curriculum can place sufficient emphasis on the development of pupils' thinking and that the appropriate use of computers can assist students in further developing their mathematical thinking and reasoning skills. These teachers also reported that the integration of ICT in the teaching and learning of mathematics can assist teachers in teaching problem solving skills, an essential and core part of the mathematics curriculum.

The themes emerging from the analysis of teachers' beliefs and concerns about the expected integration of ICT in the mathematics curricula converge to offer a grounded model for the innovation. This model underlines the importance of teachers' training and knowledge on the various aspects that are related with the integration of ICT in mathematics. Furthermore, teachers appeared to be very positive about the innovation and that they expect that the role of ICT will assist the teaching and learning of mathematics. This result is very prominent and encouraging, considering that the majority of these teachers were not well informed about the innovation from educational authorities, but were rather themselves positive and they believe that the role of technology can positively influence the role and impact of school mathematics on student learning and problem solving abilities.

In the future, a longitudinal study could be conducted to examine the development of teachers' beliefs and concerns over the first steps of the innovation. Since teachers appear to have quite strong and positive beliefs and they expressed their willingness to adopt and use the new curriculum, a study on the development of their concerns and beliefs over a long period could provide more useful information for practitioners and researchers. To better examine the research questions that guided the present study, it is recommended that a comparative study could be conducted to examine the differences between pre-service and in-service teachers' concerns and beliefs towards the new technology based mathematics curriculum, and to identify how the more technology experiences pre-service teachers have might influence their concerns and beliefs about the innovation.

Teachers' beliefs and concerns are an important issue for the successful integration of the ICT in the mathematics curricula, and this study examined this issue in relation to elementary school teachers in Cyprus. It is expected that such explorations can suggest good practices for educational authorities and teacher educators. Finally, the findings discussed would provide avenue and references for future studies.

REFERENCES

British Educational Communications and Technology Agency (BECTA) (2004). ImpaCT2. Retrieved http://publications.becta.org.uk/download.cfm?resID=25841, 28 September 2008.

Chamblee, G., & Slough, S. (2002). Implementing Technology in Secondary Science and Mathematics Classrooms: Is the Implementation Process the Same for Both Disciplines? *Journal of Computers in Mathematics and Science Teaching*, *21*(1), 3-15.

Christou, C., Eliophotou-Menon, M., & Philippou, G. (2004). Teachers' concerns regarding the adoption of a new mathematics curriculum: An application of CBAM. *Educational Studies in Mathematics, 57*(2), 157-176.

Ghaith, G., & Shaaban, K. (1999). The relationship between perceptions of teaching concerns, teacher efficacy, and selected teacher characteristics. *Teaching and Teacher Education,15,* 487-496.

Gibson, I. W. (2001). At the Intersection of Technology and Pedagogy: considering styles of learning and teaching. *Journal of Information Technology for Teacher Education*, *10*(1), 37-61.

Hall, G. E., & Hord, S. M. (2001). *Implementing change: patterns, principles and potholes*. Boston: Allyn and Bacon.

Hord, S. M., Rutherford, W. L., Huling-Austin, L., & Hall, G. E. (1998). *Taking charge of change*. Austin, TX: Southwest Educational Development Library.

Hennessy, S., Ruthven, K., & Brindley, S.(2005). Teacher perspectives on integrating ICT into subject teaching: commitments, constrains, caution, and change. *Journal of Curriculum Studies, 37*(2), 155-192.

Hossain, S. (2000). Stakeholder identification and analysis in the adoption of IT in education. MSc Dissertation. Uxbridge, UK: Brunel University.

Luehmann, A. L. (2002). Powerful Hidden Forces Affecting Teachers' Appraisal and Adoption of Innovative Technology - Rich Curricular Supports for Secondary Water Quality Learning. *American Educational Research Association*. New Orleans, LA.

Olson, J. (2000). Trojan horse or teacher's pet? Computers and the culture of the school. *Journal of Curriculum Studies, 32*(1), 1–8.

Van den Berg, R., Sleegers, P., Geijsel, F., & Vandenberghe, R. (2000). Implementation of an innovation: meeting the concerns of teachers. *Studies in Educational Evaluation*, 26, 331-350.