The effect of integrating technology in teaching as part of teachers' PCK on students' attitude, misconceptions, and mathematical problem solving performance

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Abstract— The results of the researches have indicated that pedagogical content is an essential and critical element in determining a teacher's success in handling the teaching and learning process and further produces effective teaching. This paper is going to investigate the relationship between integrating of technology as part of teachers' PCK on attitude toward fractions, misconceptions and mathematical problem solving performance of the fifth grade students in the elementary school. 24 teachers and 476 students were employed as participants in this study. A check list consist of 12 items which using technology was one of the items was implemented to measure PCK of the teachers. The checklist was made according to classification of teachers' PCK Jang et al (2009). Based on the research result, a significant relationship between using technology and with PCK' teachers was found (r= 0.810, P<0.01). In addition, the results indicated a significant relationship between using technology in classroom by teachers with student's attitude(r= r=0.549, p<0.05), misconceptions and their mathematical problem solving performance.

***Keywords*—** Pedagogy content knowledge (PCK), Educational technology, Attitude; Misconception, Problem solving performance.

I. INTRODUCTION

PEDAGIGICAL content knowledge is identified as a critical component of the knowledge which needs to teach by teacher educators and researchers and it is very important for a teacher to master it in order to be able to convey lesson content to students effectively [4]. PCK stated as a combination of content knowledge, knowledge about the students and a variety of how content knowledge is applied in a classroom's teaching and learning process [13]. For instance, using technology by teachers in classroom is one way which teachers' content knowledge is applied in teaching and learning process.

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A teacher predicts complications that may be faced by students with PCK and thus prepare themselves with methods, explanations including useful and suitable analogies or representation /symbols in expressing certain lesson topics [5]. Pedagogical content knowledge is different from both content knowledge and general pedagogical knowledge. Content knowledge is the knowledge held by a content expert, what the research chemist understands about the discipline of chemistry, however general pedagogical knowledge refers to the knowledge of experienced teachers, such as knowledge of how to organize a classroom and manage students during instruction. In addition, it refers to the teacher's understanding of content-specific examples that best represent specific topics, and knowledge of common student difficulties with specific topics. Teachers are responsible to play the active role in the process of teaching and learning of mathematics until the desired change of behaviour among students take place. For effectiveness teaching of the mathematics topics educator or teacher should acquire an in depth knowledge of the mathematics lesson intended to be taught [21]. And also the pedagogical knowledge that suits the level of the students taught [5]. The most important factor in learning process from the teaching strategy is how far the strategy used could assist students in a meaningful lesson. Hence, how a teacher uses what he knows to perform the teaching task is most important factor which help him has effective teaching and perform the teaching task.

Content knowledge, knowledge about the students and the various ways of using content knowledge in a classroom's teaching and learning process indeed play a role and integration of this knowledge is recognized as Pedagogical Content Knowledge (PCK) [13]. Literature reviews indicate that pedagogical content is an essential and critical element in determining a teacher's success in handling the teaching and learning process and further produces effective teaching [29]. According to the U.S. Department of Education's NETP model (2010), a renewed focus is calling on better preparing new teachers to use technology in innovative ways. Based on this idea, technology skilled students need technology-skilled teachers. The NETP recommended that although some pre-service teacher education programs are using technology in innovative ways, but they are not well prepared to use technology in their practice. There are some other researches which have also suggested teachers remain largely unprepared to make use of technology in the classroom [7]. In order to achieve the competence of using technology by teachers in their teaching there have been formulated several training strategies, one of them being cooperative work through small groups called base-groups on usage of technology in their classroom. This way, teachers can use their own experience in order to motivate cooperative work in their students [15,16]. Despite other teacher collaborative methodologies such as the ones presented in [25,10], we will use only lecturing collaborative techniques.

The term educational technology is related to instructional theory and learning theory and instructional technology covers the processes and systems of learning and instruction, educational technology includes other systems used in the process of developing human capability. Educational Technology consists, however is not limited to, software, hardware, as well as Internet applications and activities. But there is still debate on what these terms mean [20]. During the last decade, the design of constructivist learning environments was considered by educators, Institutes of education and instruction departments. The aim of constructivist instructional design is providing of generative mental construction “tool kits” (Jonassen, 1991) embedded in relevant learning environments that facilitate knowledge construction by learners. Constructivism makes a different set of assumptions about learning and suggests new instructional principles compared to traditional instructional systems approaches [17]. Nowadays instructors and researchers try to design active learning environments and combine them with new technologies in order to more effective learning.

One of the strategies which can improve mathematics' teachers’ pedagogical content knowledge is integrating technology in mathematics teaching process. Using technology as training for teachers could provide a comprehensive opportunity to them develop their PCK to teach in schools and college. Using technology by teachers in teaching mathematics directly effects on students’ learning. In the early years of teaching mathematics, aggravated by the fact that students do not like Mathematics and find it difficult to learn. It is in this context that the Information and Communication Technology (ICT) are vital because they can make learning funnier [32]. Learning and teaching are two main parts of a teaching process. From traditional approached to the modes of teaching with implementing of technology, the focus on the process of teaching has changed. The implementing of technology in teaching and learning has considerably changed the teaching process [27]. Learning takes place as an active, cognitive, constructive, significant, mediated and self-regulated process [16]. To make it possible teachers need to increase their content knowledge in implementing the technology in their teaching process. The use of technology in teaching mathematics is still uncommon due to the lack of teacher training, lack of material resources. However technology usually is implementing as tool to assist students in their exploration and discovery of concepts, in the transition from concrete experiences to abstract mathematical ideas, and in the process of solving problems, but only as an aid and not as purpose of education.

Attitude toward mathematics as a factor plays an important role in mathematics education. Research in this area has a long history in mathematics education. It has came originally from social psychology ([1]), in connection with the problem of foreseeing individuals’ choices in contexts like voting, buying goods, etc. In the field of mathematics education, according to Neale (1969) attitude refers to the belief that *'something called "attitude" plays a crucial role in learning mathematics,* but relationship and connection between a ‘positive’ attitude and achievement has not been reached[24]. For instance, a study carried out by Ma & Kishor (1997) on correlation between achievement and attitude, after analyzing the correlation of attitude / achievement in 113 classical studies, underline that this correlation is not statistically significant[22]. In the classification which done by Mc Leod (1992) the attitude is considered together with *beliefs* and *emotion* one of the constructs that constitute the affective domain (De Bellis & Goldin, 1999, propose *values* as a fourth construct) [23,8].

In a simple definition of attitude, it is described as the positive or negative degree of affect associated with a certain subject. Therefore, the attitude toward mathematics is just a positive or negative emotional disposition toward mathematics (McLeod, 1992; Haladyna, Shaughnessy J. & Shaughnessy M., 1983) [23,11]. The definition of ‘positive’ or ‘negative’ attitude toward mathematics refers to the definition of attitude. With regard to the attitude definition which mentioned in above, a ‘positive’ attitude is a positive emotional disposition toward the subject; a ‘negative’ attitude is a negative emotional disposition toward the subject.

The facilities with fraction for students appear not to have fully developed an understanding that fractions are numbers (e.g., Kerslake, 1986) [18]. According to Kerslake (1986) the fraction should be understood as an extension of the number system. She presented some difficulties of 12 to 14 year old students which faced in connection with fractions. She suggested those difficulties occur because students see fractions as only parts of a shape or quantity and not as numbers. The part-whole model was the only interpretation familiar to all students who took part in that study. Kerslake believes that the problem of the fractions starts in primary school when fractions are first introduced merely as parts of geometric pictures. She express that students in their school practice does not obtain enough hints to know fractions as numbers. The work with algebraic equations, graphs, and number patterns usually involves only integers. In a research which conducted by Dickson (1984) indicated that students have difficulties in identifying the unit in part whole diagrams showing more than one unit[18].

The results of a study indicated that students have difficulties in identifying a proper fraction in a number line showing two units instead of one unit of length (e.g., Kerslake, 1986 and Hannula, 2003). In addition, a common misconception of fractions is to place the fraction 1/n at (1/n) th of the distance from 0 to 2. It seems the identification of the unit in number lines is problematic to some students as in part-whole diagrams. Bell et al. (1985) mentioned that some misconceptions may come from new concepts which have not been connected strongly with the student's previous concepts. In fractions' concepts, students may see them merely as a pair of two whole numbers, one written on top of the other. However, in rational number, students should be able to both differentiate and integrate whole numbers and fractions[6].

The aim of this study is investigating of the correlation between integrating of technology by teachers with the mathematics teachers' PCK and students' attitude, misconceptions and mathematical problem solving performance.

II. Methodology

In this study the PCK of the 24 teachers of fifth grade as participants and attitude, misconceptions and mathematical problem solving performance of 476 students as participants were measured. A checklist includes 12 items with four sections was used to measure teachers' PCK. Each part consists of 3 items which was made based on five-scale items of Likert. The checklist was also made according to the classification of PCK Jang et al. (2009) [14]. In Jang's study PCK includes 4 categories: Subject Matter Knowledge (SMK), refers to students' perceptions of the extent to which the teacher demonstrates a comprehension of the subject matter and ideas within the discipline. The construction process of content knowledge and entire structure and direction of subject knowledge are also included. Instructional Representation and Strategies (IRS), refers to students' perceptions of the extent which the teacher uses a representational repertoire including analogies, metaphors, examples, and explanations, and the teacher selects teaching strategies if benefit the content learning, including informational technology. Instructional Objects and Context (IOC), comprises knowledge about the aims and process of education. IOC also includes the interactive atmosphere in the curriculum, teachers' attitudes, knowledge related to classroom management, knowledge of school setting, and instructional values. and Knowledge of Students Understanding (KSU), refers to college students' perceptions of the extent to which the teacher evaluates student understanding before and during interactive teaching, and at the end of lessons and units.

The researcher himself observes the process of teachers' teaching in the classrooms and evaluates the method of teaching. Depending on the teachers' use of different parts of PCK, the researcher gives scores 1 to 5 to each item. The total number of the scores constitutes the PCK of the teacher. For measuring students' attitudes to fractions a researcher-made questionnaire- comprising 20 items-was designed. The questionnaire also involved five components which are as follows: fear, motivation, pleasure, importance, and faith to fractions. Also for measuring of students' misconceptions in fractions, we used a test that included common misconceptions and it was comprising 10 problems. In addition, to measure infractions problem-solving performance another researcher-made test including 10 problems was made. The questionnaire comprises five conceptual problems and five procedural ones. In present study particular attention has been paid to educational-aid tools and educational technology and utilizing educational technology has been placed in Instructional Representation and Strategies (IRS).

A. Checklist of PCK measurement Subject matter knowledge (SMK)

A1: Mastery of the teachers on the content.
A2: Clarification or explanation of the content on part of the teachers.
A3: Ability of the teachers to give accurate and right answers to students questions.

B. Instructional Representation and Strategies (IRS)

A4: Teachers' capability in using right examples and illustration to make the explanation clear.
A5: using of educational technology and educational-aid tools by the teachers.
A6: Teacher's use of different approaches and methods to transfer his knowledge.

C. Instructional Objects and Context (IOC)

A7: Teachers' classroom management and creating stimulating and participating atmosphere.
A8: Presenting the aims of the lesson from the beginning of each session by the teachers.
A9: Teachers' ability to inspire students to learn more Knowledge of Students Understanding.

D. Knowledge of Students Understanding (KSU)

A10: Assessing the background knowledge of the students to start teaching new materials.
A11: Evaluating the students' understanding and learning in the process of learning.
A12: Teachers' familiarity with common mistakes and misconceptions of students and bring up some examples in this regard.

III. Findings

Table I indicates the relationship between total PCK score with each time of checklist. The results of data analysis in Table 1 showed that there is a significant relationship between using technology which is fifth item(A5) with PCK ($r=0.81$, $p<0.01$). In fact, the result is wonderful because correlation between using educational technology and PCK was more than other correlations.

Table I: Correlations

		A1	A2	A3	A4	A5	A6
PCK	Pearson Correlation	.521**	.529**	.614**	.758**	.810**	.589**
	Sig.(2-tailed)	0.009	0.002	0.001	0.000	0.000	.002

		A7	A8	A9	A10	A11	A12
PCK	Pearson Correlation	.627**	.409*	.446*	.618**	.705**	.750**
	Sig.(2-tailed)	0.001	0.048	0.029	0.001	0.000	.000

In this study the average scores of teachers' PCK was 46.64 therefore, the teachers whose PCK scores equal or more than 46, were classified as successful teachers and those whose PCK scores were equal or less than 45 were categorized as unsuccessful. The results of T-test showed that there is significant difference between successful and un-successful teachers on using technology (t [22]= 6.1, p<0.01). The results are summarized in Table (II &III).

Table II: Statistics results

	factor	N	Mean	Std. Deviation	Std. Error Mean
A5	Success	11	3.90	0.53	0.16
	Un-success	13	3.10	0.04	0.01

Table III :T- Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
A5	Equal variances assumed	8.39	.008	6.102	22	0.000	0.909
	Equal variances not assumed			5.590	10.00	0.000	0.909

In current study, first, the average scores of problem-solving and students' attitude in each classroom were calculated and then their correlation was investigated with using technology by teachers in the classrooms. As it is shown in Table (IV), there is a significant correlation between using technology in classroom by teacher with fractions problem-solving performance and attitude (r=0.549, p<0.05), (r=0.602, p<0.01). This shows that attitudes and problem-solving performance of the students whose teachers used educational technology efficiently and frequently is stronger and more positive.

Table IV: correlation

		Problem solving	Attitude
A5	Pearson Correlation	0.549*	0.602**
	Sig. (2-tailed)	0.016	0.004
	N	24	24

As mentioned, problem-solving test includes two parts: conceptual and procedural problems. The results show that there is a moderate and significant relationship between using technology with solving of conceptual problems (r=0.461, p< 0.05) whereas this relationship was not significant for procedural problems. See the results in Table (V).

Table V: Correlations

		Procedural	conceptual
A5	Pearson Correlation	0.272	0.461*
	Sig. (2-tailed)	0.13	0.03
	N	24	24

In this study, for investigation of attitude toward fractions, we use a questionnaire that was made based on a five point Likert-type scale with20 statements to be answered by indicating whether one strongly agrees, agrees, is neutral, disagrees or strongly disagrees with each statement or not. The questionnaire had negative and positive statements that measured learners' enjoyment of mathematics, motivation to study mathematics, the importance of mathematics, the freedom from fear of mathematics, and belief. Each of the five sub-variables had two negative and two positive statements.
The results of Pearson correlation showed that there is significant relationship between using of educational technology and components of attitude toward fractions. The results summarized in Table VI.

Table VI: correlation

		Enjoyment	Motivation	Important
A5	Pearson Correlation	0.713**	0.475**	0.281
	Sig. (2-tailed)	0.000	0.009	0.14
A5		Fear	Belief	
	Pearson Correlation	-0.644**	0.521*	
	Sig. (2-tailed)	0.002	0.032	
	N	24	24	24

According to Table VI, the data show that there is a significance relationship between using of technology with enjoyment, motivation, and fear of mathematics (fraction) at the p<0.01 level. While this relationship is significant at the p<0.05 level in terms of belief toward mathematics, there isn't significant relationship between technology and importance of mathematics. As you see, Pearson correlation coefficient between use of technology and fear of mathematics is -0.644 , that this shows using of technology decreases the fear of students toward mathematics.

Another result in this study was significant relationship between use of technology and misconceptions in fractions at the $p<0.05$ level. The Pearson correlation coefficient was -0.479 and sig (2-tailed) was 0.02. Some of these misconceptions were:

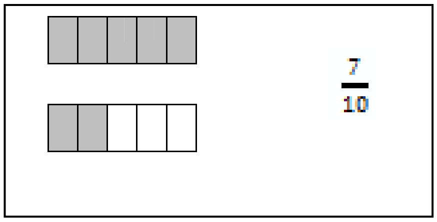

Fig .1

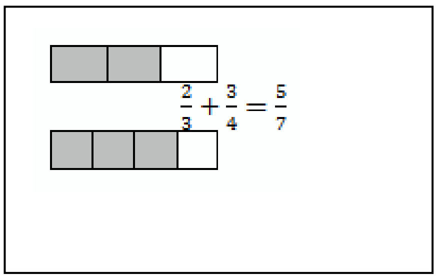

Fig.2

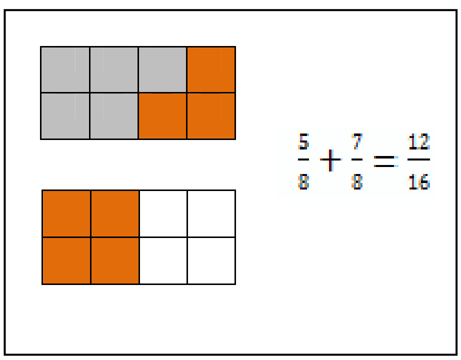

Fig.3

These misconception at the first time occurred in (Dickson et al., 1984; Amato, 2005) [2]. In the present study these misconceptions employed also. When a fraction greater than one is represented in a diagram like the one in Figure 1, many students respond 7/10 rather than 7/5. Similar problems arise when separate part whole diagrams are used to illustrate addition of two proper fractions (Figure 2) or when the total is greater than one unit (Figure 3).

Some students answered "True" to fallow equality:

$$\frac{a}{b+c}=\frac{a}{b}+\frac{a}{c}$$

Or another misconception was

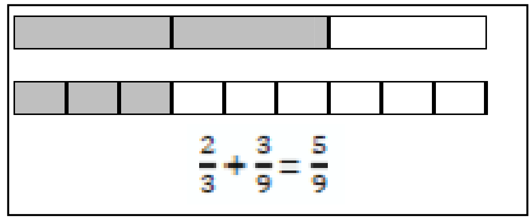

Fig .4

IV. Conclusion

PCK is a kind of knowledge that tries to find out how we can combine pedagogy and content effectively and how to use it in educational setting efficiently. Arshambulet & kripean (2009) define PCK as "knowledge about whatever that makes a subject straightforward or difficult for the learners and our knowledge about common mistakes or misconceptions and background knowledge of the learners"[3]. Pedagogical content knowledge was developed by Shulman (1986) in describing a problem within teacher education. In preparing teachers, some focused on pedagogical knowledge (teaching how to teach) while others focused their attention on content knowledge (teaching about the subject matter ie, English or mathematics). He suggested that teacher educators should focus on both the pedagogy and the content; for instance, there is something special and different about learning to teach math than there is in learning to teach science [29].

Implementing of technology with good pedagogy makes good opportunities for active participation, collaboration and social interaction. Active learning mode is a necessary component of constructivist learning theories and thus, it is also a major technological pedagogical content knowledge tenet of those theories that espouse a social perspective on learning (Prawat, 1996; Wertsch, 1991) [26]. Using technology supports and enhances active learning; however, interaction and collaboration are other important features of technology innovations. Research indicates that when children have learning collaborative, they can and do scaffold each other's thinking as predicted by Piagetian and Vygotskian learning theories (Roschelle, 1992; Tudge, 1992) and also they spend far more time in direct interaction with their peers than they do with adults (Rogoff, 1994) [28].

According to the National Council of Teachers of Mathematics (NCTM, 2000), technology is an essential tool for teaching and learning math, it is effective on mathematical content as well as the way teachers teach mathematics, and it enhances student learning. NCTM stated that technology is used by well informed teachers for supporting mathematical understanding.

In many traditional mathematics classrooms, a large group of students is leaded by teacher for demonstrating of skills follow by individual practice. In traditional mathematics classroom, teacher demonstrates the procedures to be learned and students sit in rows watching their teacher and they practice what the teacher has demonstrated). Few teachers teach their subject matter with technology and in a study which conducted by the National Center for Education Statistics found, only 20% of the current public school teachers feel comfortable using technology in their teaching (Rosenthal, 1999).Learning subject matter with technology is quite different from learning to teach that subject matter with technology. For becoming technology as a tool for learning, science and mathematics preservice teachers must also develop an overarching conception of their subject matter with respect to technology and teaching with technology calls a technology PCK (TPCK). TPCK is the integration of the development of knowledge of subject matter with the development of technology and of knowledge of teaching and learning and also it is the integration of the different domains that supports teachers in teaching their subject matter with technology. Teachers in their teaching with technology require a consideration of multiple domains of knowledge. Specially, preservice teachers need a well-developed knowledge base in their subject. They often develop subject matter knowledge over many years with a focus on personal learning and construction of how that subject is known. Developing teachers' knowledge of the subject may be takes place with development of their knowledge of technology. But, they learn about learning and teaching outside both the subject matter and technology. Preparing mathematics teachers to teach with technology offers a unique lens from which to investigate the development of TPCK. The content knowledge of technology is both scientific and mathematical. Teaching mathematics with technology is consisted major pedagogical strategies which employed in teaching mathematics. The important parts in TPCK which should be concern are: What program models support teachers in gaining the skills, knowledge, and beliefs that support teaching different subjects with technology? What are the important skills, knowledge, and beliefs? How does TPCK change for different content areas? What experiences are essential in building a TPCK? What technologies are important? What support do student teachers need as they practice teaching with technologies?

There are issues in the mathematics classroom management such as mathematics lab activities. Thus, the addition of preparing teachers to teach with technology is consistent with many of the programmatic experiences designed for the development of PCK. Fortunately, the approach of teaching of mathematics in a traditional mathematics classroom is changing. By Encouraging of the National Council of Teachers of Mathematics, use of technology in the mathematics classroom has increased, and technology-enhanced classrooms are becoming more prevalent. Certainly, the requirement to teach a sequence of lessons with technology focused the teachers on identifying potential integrations of technology in their respective curricula.

General pedagogical knowledge refers to teachers' views on teaching, managing the classroom, and learning. It is based on teachers' knowledge about the learners and learning theories; instructional principles such as cooperative learning; classroom management; and educational aims and purposes of education like promoting of problem-solving. This explains teachers' general knowledge which they have about teaching regardless of the content being taught, although it can influence how teachers come to teach particular content. Teachers' knowledge of context refers to teachers' awareness of the constraints and opportunities that they provide during the teaching process. The teachers' pedagogical content knowledge refers to a specific knowledge that allows them to make pedagogical decisions and to choose strategies that are best represent the subject matter to students. PCK is the knowledge teachers have about how to teach a particular subject matter. It is influenced by teachers' pedagogical knowledge, subject matter knowledge, and knowledge of context. A teacher who decides to use technology in the classroom must have a global understanding of what it takes to teach a particular content with technology instead of just knowing the information about the types of materials and resources available for teaching the content. The teachers should have (a) understanding of the purposes and goals for teaching with computers; (b) curriculum knowledge (materials and resources available for teaching particular subject matter such as textbooks, films, computer software) (c) knowledge of instructional strategies (appropriate ways to access content, activities, and explanations); (d) knowledge of students' understanding (conceptions or misconceptions of particular subject matter, prior background and familiarity with the content, interests within a particular field); and (e) knowledge of assessment of important aspects and the most appropriate methods to assess them. For instance providing teachers with information on students' thinking about mathematical concepts can influence the teachers' instruction and their students' achievement and their attitude toward learning.

In integrating of technology in teaching, the teacher must be aware of the purposes, goals, and aims of the unit to rely on his or her subject matter knowledge to ensure that the activity matches or reinforces the aims and goals of the curriculum. They must know the practical uses of the technology and their relation to the subject matter. For teachers who use technology as a tool for learning a similar professional development will be provided for making them aware of other teachers' (and student's) conceptions and misconceptions of microcomputer use and the strategies successful teachers use when teaching with technology. At the first the researchers and educators must understand how teachers' computer knowledge is structured and what types of knowledge are necessary to begin teaching with computers, therefore by knowing the teachers' computer knowledge, researchers can begin to determine the essential knowledge needed to teach with computers.

In this study to measure PCK of the teachers a checklist, including 12 items, was used. The checklist involves 4 parts, that is, Subject Matter Knowledge (SMK), Instructional Representation and Strategies (IRS), Instructional Objects and Context (IOC), Knowledge of Students Understanding (KSU) which according to Jang et al. (2009) was made of PCK.

The results of this study showed that there is a significant relationship between using educational technology and with PCK. Furthermore, the results show that the teachers who have higher PCK use educational technology and educational-aid tools effectively. Other results show that there is a strong and significant relationship between using technology in the classroom with attitudes, misconceptions and problem-solving performance on fraction and especially solving conceptual problems. The results of the study show that there is inverse relationship between using technology in the classroom with the fear of fractions and misconception of the students. In other words, the more the teachers use technology in the classroom, the less the students have feared of mathematics and the students acquire fundamental concepts of the subject. Thus, Teachers are strongly advised to attach high importance to various educational technology and educational-aid tools in their teaching environment.

These results are consistent with some other studies that done. For example, Souter (2002) compared the effects of technology enhanced algebra instruction and traditional algebra instruction in terms of student academic achievement, student motivation, and student attitude towards algebra. The results of her study showed Students in technology-enhanced classes had higher achievement scores, were more motivated, and had a more positive attitude than those in traditional algebra classrooms [30].

The results of Dehaven and Wiest study (2003), showed that using of technology in classroom can improve females students' attitude toward mathematics significantly [9]. In addition, the results of Topco and Ubuz study (2008), showed that web-based instruction can improve pre-service teachers' attitude, metacognition, and performance [31].

In another research, Zheng and Zhou (2006) investigated the impact of recency effect on multiple rule-based problem solving in an interactive multimedia environment. The Results show that students in the synchronized interactive multimedia group outperformed their counterparts in the unsynchronized interactive multimedia group in terms of response time and test scores. Results also indicated that low spatial ability learners in the synchronized interactive multimedia showed an improvement in problem solving [33].

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