INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 1, Issue 2, (2012) E-ISSN: 2226-6348

The Effect of Web-Based Mathematics Instruction on Mathematics Achievement, Attitudes, Anxiety and Self Efficacy of 6th Grade Students

Cem Oktay Guzeller

Assistant Professor, Department of Education Sciences, Faculty of Education, Akdeniz University, Turkey

Email: cemg@akdeniz.edu.tr

Ayca Akin

Research Assistant, Department of Elementary Education, Faculty of Education, Kastamonu University, Turkey

Email: aycaakin07@gmail.com

To Link this Article: http://dx.doi.org/10.6007/IJARPED/v1-i2/15766 DOI:10.6007/IJARPED/v1-i2/15766

Published Online: 29 July 2012

Abstract

The purpose of this study was to investigate the effects of web-based mathematics instruction (WBMI) on the mathematics achievement, attitudes, anxiety, and mathematical self-efficacy of 6th grade students. This is a study based on the pretest-posttest control group design. The experimental groups were chosen from among students who had access to computers and the internet at home. Overall, 12 students of study group had access to computers and the internet at home, and therefore there were 12 and 50 students in the experimental and control groups respectively. This study employed two different treatments. The treatment for the students in the experimental group were taught by the WBMI whiles the students in the control group were received the 6th grade mathematics content through traditional mathematics instruction (TMI), as suggested in the curriculum. The differences between the two groups were tested by the Mann-Whitney U test. The results of the study revealed that there is a statistically significant difference between the groups on the post-mathematics achievement test, postmathematics attitudes, anxiety, and self-efficacy scores in favor of experimental group. It could be concluded from the results that the use of WBMI was superior to the TMI.

Keywords: Web-based Mathematics Instruction (WBMI), Mathematics Achievement, Mathematics Attitudes, Mathematics Anxiety, Mathematics Self-Efficacy.

Introduction

21st century is called an information age. In this information age, the developments in science and technology influence the structure of the economy, society and educational systems, and information and communication technology (ICT) has provided enormous opportunities for developments all around the world (Kari, 2007). Rapid growth and development in ICT has conduced to the diffusion of technology in education (Corbett & Willms, 2002); therefore, ICT is nowadays indispensable for educational studies, such as surveys, presentations, project work or research, online and distant and web-based learning. Not only is ICT the basis of learning environment, but also it provides individuals to have lifelong learning, to improve educational outcomes, to learn new occupational skills, and to decrease inequities between groups (Cavas et al., 2004).

Educational research in mathematics indicates that students have difficulty in acquisition of mathematical concepts and fall into misconceptions (Akinsola & Animasahun, 2007; Baki & Guveli, 2008). Mathematical misconceptions may be arisen from the lack of attention and confidence when dealing with mathematics, poor academic performance (Hembree, 1990; Isiksal et al., 2009; Ma, 1999; Stuart, 2000), ineffective instruction and assessment, and ineffectual teachers.

Students in traditional mathematics instruction (TMI) listen to lecture, use standard tools of mathematics in the classroom such as pencils, rulers, and papers, read the textbook, do the corresponding homework, and take exams (Hill & Hannafin, 2001; MacGregor & Lou, 2004; Pilli, 2008). Students in TMI do not take an active part in the learning process, they do not use modern tools of mathematics, and therefore TMI cannot meet the teaching requirements in this information age (Baki & Guveli, 2008).

In this century, one of the best examples of the integration of mathematics education and technology is the web-based mathematics instruction (WBMI). WBMI is known as an online environment empowering students to interact with the others and computers individually (Pilli, 2008), to access to an abundance of resources (MacGregor & Lou, 2004), to eliminate the misconceptions by providing immediate feedback (Nguyen & Kulm, 2005; Nguyen et al., 2006; Pilli, 2008), and to provide self-directed learning to students (Morgan & O'Reilly, 2001; Reeves & Reeves, 1997). WBMI can also present a profound opportunity to improve students' practices and learning when embedded into mathematics curriculum (Nguyen et al., 2006).

Several studies revealed (e.g. Kilic, 2007; Nguyen & Kulm, 2005) that the WBMI could improve student cognitive skills and achievement, change misconceptions. The WBMI also makes students develop positive mathematics attitudes and self-efficacy. In addition to this, it makes students reduce mathematics anxiety (Crippen & Earl, 2007; Kilic, 2007; Nguyen et al., 2006).

Baki and Guveli (2008) developed a web-based mathematics instruction (WBMI) material suitable for the students of the 9th grade teaching the function concept in mathematics and they intended to evaluate the effectiveness of the material in math instruction. The analysis of the results suggested that WBMI had a positive effect on students' learning of mathematical functions and students' attitudes towards WBMI. However, some teachers in the study suggested that successful implementation of WBMI might be problematic due to the technical problems and willingness of the teachers and the students.

Kilic (2007) conducted a study in order to investigate the effects of Webquest assisted cooperative learning on the mathematics achievement and attitudes of 5th grade students. Results indicated that Webquest assisted cooperative learning had improved mathematics achievement and a positive attitude towards mathematics.

Nguyen, Hsieh and Allen (2006) performed a research so as to examine the comparative efficiency of web-based assessment and practice, and traditional assessment and practice on improving middle school students' mathematics learning attitudes. The results revealed that the experimental group students made more improvement on problem solving skills and a positive mathematics attitude, and reducement on mathematics anxiety.

Maag (2004) carried out a research to determine the effectiveness of an online interactive multimedia-learning tool versus text only, text and images, and multimedia learning explanations on mathematics achievement, mathematical self-efficacy, and student satisfaction. The results of the posttest and retention mathematics performances and mathematical self-efficacy scores revealed no significant differences between the control group and the interactive multimedia group. Crippen and Earl (2007) also indicated that the webbased worked example with a self-explanation prompt produced improvement in performance, mathematical self-efficacy and problem solving skills.

Although the results of above-mentioned studies provide some guidance to what can be anticipated in the effects of web-based mathematics instruction on the mathematics achievement, attitudes, anxiety and mathematical self-efficacy, these studies are rare. Therefore, more study that investigates the effect of WBMI on mathematics achievement, attitudes, anxiety and mathematical self-efficacy of different grade levels students should be needed (Nguyen & Kulm, 2005).

Aims of the Study

The purpose of this study was to investigate the effects of WBMI on the mathematic achievement, attitudes, anxiety, and mathematical self-efficacy of 6th grade students. This study sought to investigate the following questions

1. Is there a significant difference between the means of the post-test mathematics achievements scores corrected according to the pre-test achievements scores of the control group taught according to the TMI and the experimental group taught according to the WMBI?
2. Is there a significant difference between the means of post-test mathematics attitudes scores corrected with respect to the pre-test scores of the control group taught according to the TMI and the experimental group taught according to the WBMI?
3. Is there a significant difference between the means of post-test mathematics anxiety scores corrected with respect to the pre-test scores of the control group taught according to the TMI and the experimental group taught according to the WBMI?
4. Is there a significant difference between the means of post-test mathematical selfefficacy scores corrected with respect to the pre-test scores of the control group taught according to the TMI and the experimental group taught according to the WBMI?

Method

An experimental research model with pre-test/post-test control group which was considered as appropriate to this study to examine the effect of WBMI on students’ mathematics achievement, attitudes, anxiety and mathematical self-efficacy compared with the TMI.

Study Group

This study took place in a middle school program in a public elementary school located in Antalya. There were 62 students from sixth-grade participating in the study. The experimental groups were chosen from among students who had access to computers and the internet at home. Overall, 12 students of study group had access to computers and the internet at home, and therefore there were 12 and 50 students in the experimental and control groups respectively.

Instrument

Mathematics Achievement Test

The mathematics achievement test constructed by the researchers and it was developed based on a range of mathematics topics in the 6th grade mathematics curriculum. 25-item multiple choice questions were prepared to the mathematics achievement test and the tests were also given to six experienced elementary mathematics teachers for review. The mathematics achievement test was piloted with a group of 120 sixth grade students of another school. The reliability of the mathematics achievement test was tested, and the Kuder-Richardson 21 reliability coefficient of it was found to be .79.

Mathematics Attitudes Scale

The mathematics attitudes scale was created by Baykul (1990), who developed the instrument to assess the mathematics attitudes of elementary students. The mathematics attitudes scale consisted of 30 items-fifteen positively worded and fifteen negatively worded-using 5 likerttype scale. Coefficient alpha indicated that the instrument had strong internal consistency (Cronbach's α= .94).

Mathematics Anxiety Scale

The mathematics anxiety scale, which was assessed the mathematics anxiety of elementary students, was developed by Bindak (2005) and the scale consisted of 10 items which were rated on a 5-point (agree–disagree) scale. Cronbach alpha internal consistency for the scale was found to be .84.

Mathematical Self-Efficacy Scale

The mathematical self-efficacy scale created by Umay (2002), who developed the instrument to assess the mathematics attitudes of pre-service mathematics teachers. The mathematical selfefficacy scale consisted of 14 items-eight positively worded and six negatively worded-using 5 likert-type scale. Cronbach alpha internal consistency for the scale was found to be .70.

Research Design and Procedure

This study was conducted during the fall term of 2010–2011 academic years for six weeks at an elementary school in Antalya, Turkey. The pretest-posttest non-equivalent group design was used to collect quantitative data to determine whether there was any significant difference between the mathematics achievements, attitudes, anxiety, self-efficacy of students taught by the WBMI and those taught by the TMI. The experimental groups were chosen from among students who had access to computers and the internet at home. Overall, 12 students of study group had access to computers and the internet at home, and therefore there were 12 and 50 students in the experimental and control groups respectively. This study employed two different treatments. The treatment for the students in the experimental group were taught by the WBMI whiles the students in the control group were received the 6th grade mathematics content through TMI (teacher-centered), which is a predominant approach in Turkish Educational System (Cepni et al., 2006), as suggested in the curriculum. Educational activities for the experimental group had a Web site designed by the researchers that displayed animations, basic explanations, examples, games, questions, interactive exercises for the 6th grade mathematics topics including: angles, absolute value, numbers, patterns and ornaments, polygons, similarity and congruency, and whole numbers. You can also reach the website used in this study from http://akdeniz.freei.me.

Some pages of website

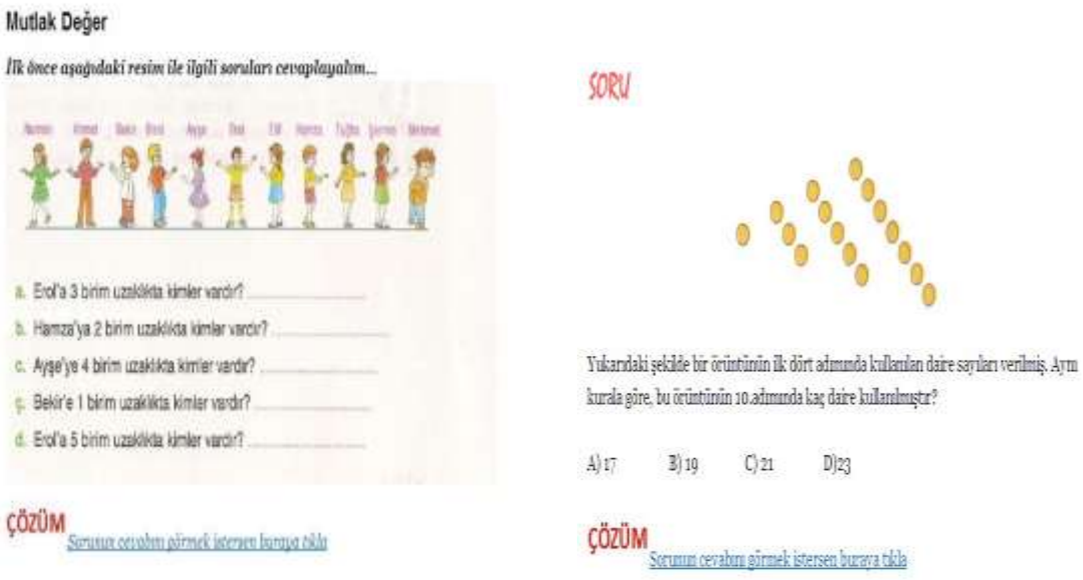

Figure 1. Mathematical questions from the website

Figure 2. Mathematical question solution from the website

Prior to the study, students in experimental and control groups took the mathematics achievement test, and mathematics attitudes, anxiety, and self-efficacy pre-test. At the end of the experiment, students in both WBMI and TMI took the mathematics achievement test, and mathematics attitudes, anxiety, and self-efficacy post-test.

Analysis

The differences between the two groups were tested by the Mann-Whitney U test with the assistance of statistics program SPSS 17.0. Because the size of the sample is small (size < 15), non-parametric assumptions underlying the test hold (Qian, 1997). The Mann-Whitney U test is usually employed for this type of analysis. The Mann–Whitney U test was used to determine if there were any statistically significant differences in the mathematics achievement, attitudes, anxiety, and self-efficacy of 6th grade students in the experimental and control groups.

Results

Students' Mathematics Achievement

As could be seen in Table 1, the mathematics achievement pre-test means of experimental group and control group was 6.66 and 7.16, respectively. It was found in a Mann- Whitney U test (U = 287.5, p > .05) that there was no significant difference between the mathematics achievement pre-test scores of the students in the two groups. This meant that the groups were performing at the similar levels upon entering the course. At the end of the treatment, there was a statistically significant difference in the mathematics achievement posttest scores in the two groups (U = 160.5, p < .05). The performance of the TMI group (control) was lower with a mean rank of 28.71 and post-test mean of 12.88 as compared to the WBMI group (experimental) with a mean rank of 43.13 and post-test mean of 17.16. This therefore indicated that the WBMI was more effective at mathematics achievement in experimental group than control group.

Table 1

Results of the Mann–Whitney analysis on students' pre and post tests mathematics achievement scores of experimental and control groups.

The study groups		*N*	Mean rank	Mean	Standard deviation	Pvalue
Pre-test scores of the groups	Experimental	12	30.46	6.66	3.49	.82
	Control	50	31.75	7.16	2.39	
Post-test scores of the groups	Experimental	12	43.13	17.16	3.76	.01
	Control	50	28.71	12.88	4.87	

Students' Mathematics Attitudes

The means related to mathematics attitudes of the experimental and control groups before the commencement of the treatment were 3.85 and 3.44, respectively and there was not statistical significant difference between the mathematics attitudes pre-test scores of the students in the two groups (U= 225.5, p > .05). On examination of the mean post attitudes scores, it was found that the group with web-based instruction environment was 4.03 and the other group mean was 3.54 and there was a statistically significant difference in the mathematics attitudes posttest scores in the two groups (U = 165, p < .05). The mathematics attitudes scores of the TMI group (control) was lower with a mean rank of 28.80 as compared to the WBMI group (experimental) with a mean rank of 42.75 (Table 2). This meant that students in the WBMI group had a significantly better attitude development.

Table 2
Results of the Mann–Whitney analysis on students' pre and post tests mathematics attitudes scores of experimental and control groups

The study groups		*N*	Mean rank	Mean	Standard deviation	Pvalue
Pretest scores of the groups	Experimental	12	37.71	3.85	.72	.18
	Control	50	30.01	3.44	.99	
Post-test scores of the groups	Experimental	12	42.75	4.03	.40	.02
	Control	50	28.80	3.54	.70	

Students' Mathematics Anxiety

According to the data in the table 3, there was not statistical significant difference between the mathematics anxiety pre-test scores of the students in the two groups (U= 26.5, p > .05), and the mathematics achievement pre-test means of experimental group and control group was 2.29 and 2.44, respectively. At the end of the treatment, there was a statistically significant difference in the mathematics anxiety posttest scores in the two groups (U = 182.0, p < .05). The mathematics anxiety scores of the WBMI group (experimental) was lower with a mean rank of 21.67 and a post-test mean of 1.71 as compared to the TMI group (control) with a mean rank of 33.86 and a post-test mean of 2.6. This implied that the WBMI was reduced students' mathematics anxiety, whereas the TMI was increased students' mathematics anxiety levels.

Table 3
Results of the Mann–Whitney analysis on students' pre and post tests mathematics anxiety scores of experimental and control groups.

The study groups		*N*	Mean rank	Mean	Standard deviation	Pvalue
Pretest scores of the groups	Experimental	12	28.63	2.29	1.03	.54
	Control	50	32.19	2.44	.91	
Post-test scores of the groups	Experimental	12	21.67	1.71	.61	.04
	Control	50	33.86	2.6	1.27	

Students' mathematical self-efficacy

The students in WBMI performed significantly better on the mathematical self-efficacy posttest than the students in TMI as could be seen from Table 4. This seemed to suggest that the WBMI made students develop a positive mathematical self-efficacy, while the TMI made students reduce a positive mathematical self-efficacy.

Table 4
Results of the Mann–Whitney analysis on students' pre and post tests mathematical self-efficacy scores of experimental and control groups.

The study groups		*N*	Mean rank	Mean	Standard deviation	Pvalue
Pretest scores of the groups	Experimental	12	34.79	3.55	.70	.48
	Control	50	30.71	3.45	.64	
Post-test scores of the groups	Experimental	12	42.13	3.63	.74	.02
	Control	50	28.95	3.13	.88	

Discussion

The purpose of this study was to examine the effects of WBMI on the mathematic achievement, and attitudes, anxiety and mathematical self-efficacy of 6th grade students. Several interesting findings emerged in this study.

The result of this study was indicated that those students who received the WBMI performed significantly better than those in the TMI class. One explanation for the higher achievement by the WBMI group versus traditional group was that all of the students in WBMI received immediate and adapted feedback on example and question items (Mavrikis & Maciocia, 2003; Nguyen & Kulm, 2005), and could receive and retake each examples and questions as many times as they wanted (Mavrikis & Maciocia, 2003; Nguyen & Kulm, 2005). This finding supported the findings of previous studies which revealed that the WBMI was highly influential to improve student mathematics achievement (e.g. Crippen & Earl, 2007; Kilic, 2007; Nguyen et al., 2006; Nguyen & Kulm, 2005; Sanchis, 2001). Although this result of the present study was inconsistent with Baki and Guveli (2008); Maag (2004) which shown that the results of the mathematics achievement posttest scores indicated no significant difference between the WBMI group and the control group.

The results were indicated that students in the WBMI proned to develop positive mathematics attitudes and mathematical self efficacy than students in the TMI. Besides, it was found that students' mathematical self-efficacy were quite negative in the TMI class at the end of study. This situation could be explained that the WBMI was improved students' confidence in mathematics problem solving, and increased positive attitudes toward learning and it not only given students with more practice, but also helped them made better self-motivation, selfconfidence, and self-efficacy (Nguyen et al., 2006). Several studies (Baki & Guveli, 2008; Nguyen & Kulm, 2005; Nguyen et al., 2006) also revealed that students in the WBMI found mathematics more enjoyable. This result was consistent with past studies (Baki &
Guveli, 2008; Crippen & Earl, 2007; Gressard & Loyd, 1985; Jung et al., 2002; Koszalka, 2001; Kulm, 1994; Nguyen & Kulm, 2005; Nguyen et al., 2006) which indicated that the WBMI improved students' mathematics attitudes and mathematical selfefficacy. The result of this study was also shown that the WBMI was reduced students' mathematics anxiety, while the TMI was increased students' mathematics anxiety level. From this result, it could be explained that students in the WBMI made more reducement on mathematics anxiety. Also, it provided students, who had a high level of mathematics anxiety, to recognize their scores immediately; therefore, they might felt less math-anxious, and have more control over their learning mathematics (Nguyen et al., 2006).

Conclusion

In summary, the results of this study were shown that students in the WBMI made more improvement on mathematics achievement, a positive mathematics attitude and mathematical self-efficacy, and reducement on mathematics anxiety. Students in the WBMI were also provided with receive immediate and adapted feedback and the opportunity of more practice for better mathematics achievement scores (Nguyen & Kulm, 2005). It could be concluded from the results that the use of WBMI was superior to the TMI.

Suggestions

The results of this study revealed that the WBMI could offer an opportunity to improve students' mathematics achievement, attitudes, and mathematical self-efficacy, and to reduce students' mathematics anxiety. Further studies should be carried out with different mathematical contents and grade levels in order to confirm the actual benefits of WBMI.

The students in the initial stages of the primary education should be made familiar with the WBMI, since web based instruction has provided profound opportunities for learning mathematics (Baki & Guveli, 2008). But, the results of PISA 2009 show that in Turkey, access to a computer and link to the internet at school and at home are still too low (Guzeller & Akin, 2011). In order to improve the quality of learning environment for students who have not access to computers and the internet at home and at school; obstacles to the access to computers and internet at home and at school should be removed as soon as possible, while investments should be encouraged.

References

Akinsola, M. K., & Animasahun, I. A. (2007). The effect of simulation-games environment on students' achievement in and attitudes to mathematics in secondary schools. *The Turkish Online Educational Technology*, *6*(3), 113-119.

Baki, A., & Guveli, E. (2007). Evaluation of a web based mathematics teaching material on the subject of fractions. *Computers & Education*, 51, 854-863.

Baykul, Y. (1990). *To what extent the students' attitudes towards mathematics and science subjects were changed in the Turkish schools in grades five through eleven, the factors which might have some significant relation with the student performance in student selection exam*. OSYM Publishing, Ankara, Turkey.

Bindak, R. (2005). Mathematics anxiety scale for primary school students. *Science and Engineering Journal of Firat University, 17*(2), 442−448.

Corbett, B.A., & Willms, J.D. (2002). Canadian students' access to and use of information and communication technology. *Paper presented at 2002 Pan-Canadian Education Research Agenda Symposium Information Technology and Learning,* 30 April - 2 May, Montreal, Quebec. Retrieved May 11, 2011 from [www.cesc.ca/pceradocs/2002/papers/BCorbett_OEN.pdf].

Crippen, K. J., & Earl, B. L. (2007). The impact of web-based worked examples and selfexplanation on performance, problem solving, and self-efficacy. *Computers & Education, 49*, 809–821.

Cavas, B., Kisla, T., & Twining, P. (2005). Egitimde bilgi ve iletisim teknolojilerinin kullanimina yonelik bir arastirma: dICTatEd yaklasimi [A study on the use of information and communication technologies in education: dICTatEd approach]. Retrieved May 11, 2011 from http://kn.open.ac.uk/public/getfile.cfm?documentfileid=4551.

Cepni, S., Tas, E., & Kose, S. (2006). The effects of computer-assisted material on students' cognitive levels, misconceptions and attitudes towards science. *Computers & Education, 46*, 192–205.

Gressard, C. P., & Loyd, B. H. (1985). Age and staff development experience with computers as factors affecting teacher's attitudes toward computers. *School Science Mathematics, 85*(3), 203–209.

Guzeller, C. O., & Akin, A. (2011). The inter-regional inequality of access to information and communication technology in Turkey based on PISA 2009 data. *The Turkish Online of Journal Educational Technology (TOJET), 10*(4), 349-354.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*, 33–46.

Hill, J., & Hannafin, M. (2001). Teaching and learning in digital environments: The resurgence of resource based learning. *Educational Technology Research and Development, 49*(3), 37-52.

Isiksal, M., Curran, J. M., Koc, Y., & Askun, C. S. (2009). Mathematics anxiety and mathematical self-concept: Considerations in preparing elementary-school teachers. *Social Behavior and Personality, 37*(5), 631–644.

Jung, I., Choi, S., Lim, C., & Leem, J. (2002). Effects of different types of interaction on learning achievement, satisfaction and participation in Web-based instruction. *Innovations in Education and Teaching International, 39*(2), 153–162.

Kari, H. K. (2007). Availability and accessibility of ICT in the rural communities of Nigeria. *Electronic Library, 25*(3), 363–372.

Koszalka, T. A. (2001). Effect of computer-mediated communications on teachers' attitudes toward using web resources in the classroom –Statistical data included. *Journal of Instructional Psychology, 28*(2), 35-44.

Kilic, R. (2007). *Webquest destekli isbirlikci ogrenme yonteminin matematik dersindeki tutum ve erisiye etkisi.* Unpublished master's thesis, Osmangazi University, Eskisehir, Turkey. Kulm, G. (1994). *Mathematics assessment: What works in the classroom.* San Francisco: Jossey Bass.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States.* Mahwah, NJ: Erlbaum.

Maag, M. (2004). The effectiveness of an interactive multimedia learning tool on nursing students' math knowledge and self-efficacy. *Computers Informatics Nursing, 20*(1), 26-33.

MacGregor, K., & Lou Y. (2004) Web-based learning: how task scaffolding and web site design support knowledge acquisition. *Journal of Research on Technology in Education,* 37, 161– 175.

Mavrikis, M., & Maciocia, A. (2003). Incorporating assessment into an interactive learning environment for mathematics. *Maths CAA Series*: June 2003. Retrieved June 8, 2011, from http://ltsn.mathstore.ac.uk/articles/maths-caa-series/june2003/index.shtml

Morgan, C., & O'Reilly, M. (2001). Innovations in online assessment, in: F. Lockwood & A. Gooley (Eds) *Innovations in open and distance learning,* Kogan Page, London.

Nguyen, D. M., & Kulm, G. (2005). Using web-based practice to enhance mathematics learning and achievement. *Journal of Interactive Online Learning (JIOL), 3*(3),1-16.

Nguyen, D. M., Hsieh, Y. J., & Allen, G. D. (2006). The impact of web-based assessment and practice on students' mathematics learning attitudes. [Electronic Version]. *The Journal of Computers in Mathematics and Science Teaching*, *24*(1), 5-25.

Pilli, O. (2008). *The effects of computer-assisted instruction on the achievement, attitudes and retention of fourth grade mathematics course.* Unpublished doctoral dissertation. Orta Dogu Teknik University, Ankara, Turkey.

Qian, G. (1997). Assessing product-market diversification of U.S. firms. *Management International Review, 37*, 127-149.

Reeves, T. C., & Reeves, P. M. (1997). Effective dimensions of interactive learning on the World Wide Web. In Khan, B. H. (ed.) *Web-based instruction*, Educational Technology Publications, Englewood Cliffs, New Jersey.

Sanchis, G. R. (2001). Using web forms for online assessment. *Mathematics and Computer Education, 35*(2), 105-114.

Stuart, V. (2000). Mathematics curse or mathematics anxiety? *Teaching Children Mathematics*, 6, 330–335.

Umay, A. (2002). İlkogretim matematik ogretmenligi programinin ogrencilerin matematige karsi ozyeterlik algisina etkisi. *Paper presented at the V. Ulusal Fen Bilimleri ve Matematik Egitimi Kongresi*. [Online] Available from: http://www.fedu.metu.edu.tr/ufbmek-5/b_kitabi/b_kitabi.htm.