PRESERVICE COMPUTER TEACHERS AS HYPERMEDIA DESIGNERS: THE IMPACT OF HYPERMEDIA AUTHORING ON KNOWLEDGE ACQUISITION AND RETENTION

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ABSTRACT
This study aims to assess the impact of hypermedia designing as a cognitive tool on knowledge acquisition and retention in comparison to traditional instruction. A pretest-posttest control group design was used. The study included 48 second-year preservice computer teachers who enrolled in "Instructional Technology and Material Preparation" course at one of the universities in Turkey. The subjects were assigned to experimental and control groups through "matched-pair technique." Both groups were given a pretest to measure their prior achievement level in "Instructional Technology & Material Preparation" course content. While the control group was exposed to traditional instruction, the experimental group developed hypermedia on the course content in a constructivist learning context for 14 weeks. A posttest was given at the end of the treatment, and a retention test was given eight weeks after the treatment to both groups. The results showed that the use of hypermedia as a cognitive tool resulted in similar level of student achievement as traditional instruction.
Keywords: Hypermedia, Cognitive tools, Computer teachers

INTRODUCTION

Computers and other related technology systems such as multimedia/hypermedia, World Wide Web and virtual reality are used in the field of education through a variety of approaches. Revees (1999a) examines these approaches in two categories. In the first, students learn *from* interactive learning systems (computer-based instruction, traditional conception of use of computers) whereas in the second, students learn *with* interactive learning systems (cognitive tools). In the *from* approach, the content is encoded in the software programs, and it is assumed that communicating with this content, students will learn it. In the *with* approach, interactive tools are used by students as cognitive tools to analyze, access, interpret, organize, and represent information. As a result of this interaction, cognitive tools are expected to promote critical thinking and higher order learning in students.

The computer technologies as cognitive tools represent a significant departure from traditional conceptions of technologies. In cognitive tools, information or solutions of problems are not encoded in the educational material to be learned, which are designed to transmit the knowledge to the learners effectively. With cognitive tools, learners function as designers and problem solvers in using the computers as tools for analyzing, accessing, interpreting and organizing their personal knowledge. In this process, computers become cognitive or mental tool helping learners' thinking in performing the learning task (Jonassen, 2000; Kozma, 1992; Mayes, 1992; Reeves, 1999a; Toomey et al., 1995). Jonassen, Carr and Yueh (1998), and Reeves (1999b) state that when computers are used by learners to represent what they know, this procedure necessarily engages them in critical thinking and higher order learning about the content they are studying. In other words, they require students to think about what they know, and learn in different and meaningful ways.

Hypermedia interactive systems can be used in both to learn *from* and to learn *with* (cognitive tools) approaches. The literature points out that when students learn *from* hypermedia, multiple representational formats such as combination of text, video, graphics, pictures and animations in a content domain through multimedia contribute to students' learning, self competence and motivation (Kafai, Ching and Marshall, 1997). However, learning *from* hypermedia is not problem free. For example, it may not be effective in supporting learning; learners may not always select the right link for effective learning; it may be inefficient if there is no guide; engagement and interactivity which is essential for learning may not be provided in an effective way; discovery learning may be questionable through browsing; and lastly disorientation and cognitive overload may create problems in learning through hypermedia (Mayes, 1993).

According to Jonassen and Reeves (1996), Jonassen (2000), and Dalgarno (2001), the use of hypermedia as a cognitive tool places students in the author's seat so that they may construct their own understanding, rather than interpreting the teacher's understanding of the environment, and they suggest that it is more efficient using hypermedia not as a source of knowledge to learn from but rather as a cognitive tool to construct and to learn with. They argue that knowledge acquisition in the design can be facilitated when learners are actively engaged in designing knowledge rather than interpreting and decoding it. Learners become designers when they focus on the purpose of acquiring information, hypermedia's underlying structure, and using the arguments required by the subject matter to justify the design. Hypermedia can be a powerful tool for engaging and supporting these activities. Therefore, providing appropriate learning environments for learners to design and present their own understanding of the subject through designing hypermedia can be an effective learning experience (Reeves, 1999a). In addition, based on their research study, Kafai, Ching and Marshall (1997) indicate that designing and creating hypermedia is a complex task and most of the time requires collaboration and teamwork, and therefore using hypermedia as a cognitive tool promotes students' collaboration and project management skills. Accordingly, Revees (1999a) acknowledged that "using multimedia construction programs as cognitive tools engages many skills in learners such as: project management skills, research skills, organization and representation skills, presentation skills, and reflection skills" (paragraph 7).

Jonassen (1998) and Revees (1999b) state that using technology as cognitive tool and learning with technology in effective and efficient ways require constructivist-learning context. "Constructivism is based on the fundamental assumption that learning is in the activity of the learner. Learning is in the doing" (Duffy and Orrill, 2001, p.1). They add that the teacher's role in this approach is to provide appropriate learning environments and guide and facilitate for learning. As it is cited in Oliver and Herrington (2003), Cunningham, Duffy and Knuth (1993) indicated that constructivist learning contexts provide experience, realistic contexts, social experience appreciation for multiple perspectives and multiple modes of representation, promote ownership, and encourage self-awareness in the knowledge formation process. Constructivist approach can be implemented best at advance level learning (Jonassen, Mayes and McAlessi, 1993). They indicate that in the learning process there are three main phases: introductory, advanced and expert learning phases.

> Introductory learning occurs when learners have little directly transferable prior knowledge about a skill or content area. It represents the initial stages of schema assembly and integration. At advanced learning phase, learners acquire more advanced knowledge in order to solve more complex domain or context-dependent problems. Experts have more internally coherent and more richly interconnected knowledge structure (p. 1).

They declare that initial knowledge acquisition phase is better served by classical instructional design while constructivist learning environments are generally more viable for the second, advanced knowledge acquisition phase. Universities and secondary education institutions exist to foster advanced knowledge acquisition with a transition to constructivist approach that represents complexity and ill-structuredness as the learner acquires more knowledge (Jonassen, Mayes and McAlessi, 1993). It can be concluded from these statements that using hypermedia as a cognitive tool in a constructivist learning context can be facilitated better at upper secondary and university education levels.

The literature indicates that use of hypermedia as a cognitive tool is effective for critical thinking, higher order learning, project management skills, reflection skills, and presentation skills (Jonassen, 2000; Jonassen & Reeves, 1996; Lehrer, 1993; Mayes, 1993). Although numerous research studies offered evidence on the positive impact of hypermedia as cognitive tools on veriey of students' skills, the literature seems to be insufficient in explaining the impact of hypermedia on knowledge acquisition and retention when hypermedia is used as a cognitive tool in a constructivist learning context at teacher education level. Since teachers are the ones who integrate technology into teaching and learning process, how hypermedia as a cognitive tool contributes to knowledge acquisition and retention in educational process needs to be explored at teacher education level as well. Additionally, in Turkey, the Higher Education Council (HEC) redesigned the curricula of teacher-education institutions to improve their quality, and to integrate information and communication technology (ICT) into these programs in 1998 (HEC, 1998). However, integration of ICT into teacher education programs has been implemented mostly at computer literacy level. Therefore, this study aims to assess the effect of use of hypermedia when it is used as a cognitive tool in comparison to traditional classroom instruction on knowledge acquisition and retention of preservice computer teachers. The following research questions guided this study.

(1) Is there a significant mean difference in knowledge acquisition between the experimental group who used hypermedia as a cognitive tool and the control group who were exposed to traditional instruction?
(2) Is there a significant mean difference in knowledge retention between the experimental group who used hypermedia as a cognitive tool and the control group who were exposed to traditional instruction?

METHOD

Design

A pre-test/post-test control group design was used in this study. Control variables of the study were prior achievement, gender and type of high school the participants graduated from; the independent variable was the treatment (hypermedia learning environment vs. traditional instruction); the dependent variables were the post-test and retention test performance of the subjects. Below, the details on the participants, the instrument and the procedures of the study are presented.

Participants

The study design included a total of 48 second-year Computer Education & Instructional Technology Education students who enrolled in "Instructional Technology and Material Preparation" course at one of the universities in Turkey, and lasted 14 weeks (two hours a week). The students in the Department of Computer Education & Instructional Technology Education are trained to be computer teachers for K-12 schools and experts in the field of instructional technology. Majority of the students graduated from computer departments of vocational or technical high schools. The students had the basic knowledge in variety of computer applications and in designing hypermedia prior to the experiment. They were assigned to experimental and control groups through "matched-pair technique" based on gender, cumulative GPA scores and the types of high schools they graduated from. From each pair, one student was assigned to the experimental group, the other was assigned to the control group randomly. By using this technique, equal representation in terms of gender, prior achievement, and prior education in both control and experimental groups was established. In the beginning of the study, the experimental group included 28 (24 males and 4 females), and the control group included 28 (24 males and 4 females) subjects. The distribution of males and females in these groups represents closely the distribution by gender in the department. During the experiment, four students in the experimental group did not participate in the majority of the activities, therefore they, together with their pairs in the control group (total of eight students), were eliminated from the analysis of the data. As a result, 24 (20 males and 4 females) students in the control group, and 24 (20 males and 4 females) students in the experimental group participated in all phases of the study.

Data collection instrument

An achievement test was used to assess the students' achievement on "instructional material development" subject before the experiment, after the experiment, and eight weeks after the experiment. The achievement test was developed by the researcher, and consisted of 44 multiple-choice questions on "instructional material development" subject. First, a table of specifications on the basis of learning objectives stated in the textbook Instructional Media and Technologies for Learning (Heinich, Molenda, Russell, & Smaldino, 2002) used in this course was constructed. Based on the table of specifications, the questions were written to establish the content validity of the test. So that lower and higher cognitive levels such as knowledge (recalling the learned subject), comprehension (understanding the meaning of the subject), application (using the learned subject in new situations) and analysis (understanding the underlying structure of the subject) were included in the achievement test. After the test was developed, two experts (a test construction specialist and a subject area specialist) assessed the test in terms of validity and relevance to the subject matter. Based on their suggestions the test was revised. After revisions, the test was piloted with a group of students (n=29) who had been taken the same course in the previous semester to check whether the items were clear and understood correctly. Afterwards, an item analysis was carried out on the test. The results of this analysis proved that one of the items in the test was too difficult for the subjects. Since the course content related to this specific item was new in the course and in the textbook used in the course, the item was not eliminated from the test. The Cronbach alpha reliability of the questionnaire was .78.

Procedures

The procedures and data analysis used in this study are presented in Table 1. At the beginning of the study, both experimental and control groups were given an achievement test to assess their prior achievement level in the course content.

Table 1: Data collection and analysis procedures

Groups	*Pretest*	*Treatment*	*Posttest (given at the end of treatment)*	*Retention test (given 8 weeks after treatment)*	*Data analysis*
Control (24 students)	Achievement test	Traditional classroom instruction (14 weeks)	Achievement test	Achievement test	Means, standard deviations, and *t* test.
Experimental (24 students)	Achievement test	Hypermedia as a cognitive tool (Hypermedia development by students on the course content, 14 weeks)	Achievement test	Achievement test	

Then, students in the experimental group were informed of the procedures of the course that the course was going to precede in a constructivist context, and hypermedia was to be used as a cognitive tool. A constructivist learning environment in which students acted as designers of hypermedia learning environments was established to have learners work in groups through social interactions as suggested by Vygotsky (1978), and construct their own knowledge in the field of "instructional technology and material preparation." To create constructivist learning environment, situated learning environment guidelines recommended by Herrington & Oliver (2000) were considered. By creating a hypermedia learning environment on the course content for preservice computer teachers, authentic context and activities were facilitated. Students had acces to the expert knowledge through weekly discussions with the instructor on the hypermedia content and template. A reflective environment was created through writing weekly reflective journal on the hypermedia content, receiving feedback on these journals, and discussing within groups both the content and design of the hypermedia. Through out the process, the group members had variety of roles such as instructional designers, programmers, project managers and etc. Through out this collaborative process, the instructor provided guidance for the students.

Throughout the semester, the students in groups had to develop hypermedia as an instructional material in "instructional technology and material preparation" subject for other preservice teachers, and they covered most of the course content in that material. The instructor did not present the course content to the students didactically, but promoted a constructivist-learning context in which she facilitated, coached and guided. During the experiment, in order to guide the students effectively, predetermined stages, namely *planning, content formation, template design, hypermedia development, evaluation,* and *presentation* were followed by the students. In the beginning of the semester, the students in the experimental group performed ***planning*** activities. In planning they were requested to form their project groups for two to five students. In the groups, they determined the tasks they need to perform throughout the hypermedia construction process, negotiated each group member's roles, and made task schedules to be followed in the hypermedia development process. As a result of their planning activities each group handed a group contract to the instructor. After planning, they started ***content formation*** of hypermedia learning environment. To determine the content of the hypermedia, the students wrote weekly reflective journals about the assigned subjects of the course content for about eight weeks, and received weekly feedback from the instructor on their journals. Based on the instructor's feedback, the groups made some revisions on their hypermedia content. While preparing their journals they used the textbook, World Wide Web, assigned resources from the university library, and related materials from other courses. During this period, they also participated in group discussions and activities held in class. This process helped them investigate the subject area deeply and decide on which information to include in the hypermedia. Parallel to content formation process, they ***designed the templates*** of the hypermedia they were to develop. While developing their hypermedia learning environment template, each group's template was discussed in class in terms of effective design principles, and each group had their classmates and instructor's assessment of their template design. In this process they decide on the structure of the hypermedia, how to present information, how to link nodes. After they finished content formation and template design, by the end of the semester they ***developed the hypermedia learning environment***. The groups used MS FrontPage, Java Scripts, Flash, PHP, and other similar tools to develop their hypermedia projects. Then they ***evaluated*** the hypermedia they developed to check if it is running properly without any problem, and made revisions. At the end of the semester they ***presented their hypermedia*** in class to share their projects with others.

The control group continued learning the "Instructional Technology and Material Preparation Course" content with regular classroom instruction mostly based on PowerPoint presentations supported by question-answer strategy (traditional instruction) while the experimental group developed hypermedia about the course content. The treatment continued 14 weeks. At the end of the treatment, the achievement test used as pre-test was given to the students in both groups as post-test. Eight weeks after the experiment, the same achievement test was given to both groups once again to measure the level of knowledge retention. The data collected through pretest, posttest and retention test were analyzed by descriptive and inferential statistics such as means, standard deviation and *t*-test.

RESULTS

Pretest results

Pretest results showed that in the beginning of the experiment the experimental group who used hypermedia as a cognitive tool had higher scores from the control group that was subjected to traditional classroom instruction (M=15.04 and 12.75 respectively) (see Table 2). However, *t*-test results indicated that the difference in the pretest mean score was not statistically significant (p>.05).

Table 2: Pretest mean score results of experimental and control groups

	N	*Mean*	*Std. Deviation*
Experimental Group	24	15.0417	4.0269
Control Group	24	12.7500	4.3564

t(46)=1.89, p=.065

Posttest results

As it is presented in Table 3, posttest results showed that at the end of the experiment, students in the experimental group who were exposed to hypermedia as a cognitive tool scored higher than the students in the control group who participated in traditional classroom instruction (M=36.83 and 35.79 respectively). However, *t*-test results indicated that the difference in the postest mean score was not statistically significant (p>.05), (see Table 3).

Table 3: Posttest mean score results of experimental and control groups

	N	*Mean*	*Std. Deviation*
Experimental Group	24	36.8333	4.0931
Control Group	24	35.7917	7.0955

t(46)=.62, p=.53

Retention test results

Retention test results (eight weeks after the experiment) showed that the students in the experimental group scored slightly higher than the students did in the control group (M=29.79 and 28.41 respectively; Table 4). However, *t*-test results indicated that the posttest-retention test gained scores mean difference of experimental and control groups (M= -7.04 and -7.37 respectively) was not statistically significant (p>.05), (see Table 5).

Table 4: Retention test mean score results

	N	*Mean*	*Std. Deviation*
Experimental Group	24	29.7917	3.7181
Control Group	24	28.4167	6.1285

Table 5: Posttest-retention test gained-score means of experimental and control groups

	N	*Mean*	*Std. Deviation*
Experimental Group	24	-7.0417	4.4573
Control Group	24	-7.3750	4.9150

t(46)=.24, p=.80

CONCLUSION

Posttest and retention test results showed that the second year preservice computer teachers in both experimental and control groups acquired and retained similar levels of knowledge in the area of "instructional technology and material development." It can be concluded from these results that the two approaches do not differ from each other significantly in regard to knowledge acquisition and retention. Literature indicates that using hypermedia as a cognitive tool helps learners analyze, access, interpret and integrate information, and facilitate reflective thinking, critical thinking and higher order learning (Jonassen, 2000; Jonassen & Reeves, 1996; Lehrer, 1993;

Mayes, 1993). To achieve all these skills, of course, one must have the knowledge base in the content area. So the assumption would then be that hypermedia, as a cognitive tool would contribute to knowledge acquisition and retention more effectively than the traditional instruction. The results of this study prove otherwise.

Several explanations can be offered in interpreting the results of this study. One of the reasons for this result may be related to the learning and study habits of the participants. The participants of this study were the second year preservice teacher education students in Turkey. Turkey's educational system is quite traditional. Throughout their school years, students might have received direct instruction most of the time. The students might have carried these study habits from the past, and developing hypermedia about the subject to be learned might be a new learning approach for them. The demanding instruction/learning process and in adapting to this new strategy might have negatively affected their knowledge acquisition and retention.

This study lasted 14 weeks, which was a long period of time. Duration of the project was consistent with the literature stating that through project-based learning, learners concentrate on complex, integrated modules of long-term instruction (Krajcik et al., 1994 cited in Jonassen 1998). However working in a group for a long period of time was a new experience for the majority of the students in the experimental group. This might have also affected their performance negatively in the post-test and retention test.

This study provides valuable information as to whether designing hypermedia as a cognitive tool in comparison with traditional classroom instruction leads to learning and to what degree. Based on the results, it can be suggested that hypermedia can be integrated into "Instructional Technology and Material Preparation" course as a cognitive tool, to provide practice opportunities in instructional material development process for prospective computer teachers. The results of this study may help practitioners gain perspective into using hypermedia as a cognitive tool in their classes, and understand what to expect in terms of knowledge acquisition and retention in teacher education context. The results of this study may also help instructional material designers/developers and those who use the material in educational settings in understanding the potential contribution and limitation of hypermedia as a cognitive tool in a constructivist learning context.

Jonassen (2000) states that using computer-based cognitive tools promotes critical thinking skills of the students. However, he indicates that it may not be possible to observe these thinking skills of the learners immediately after the application. It can be observed in later stages of their life when students face with a problem situation. In addition, the students might have gained other skills such as collaboration, problem solving, and project management skills as Kafai, Ching and Marshall (1997) indicated.

In order to interpret the findings of this study, some of the limitations need to be taken into account. In this study, small sample size was the most important limitation of the study. The number of the participants in the study was limited to the number of second year students at Instructional Technology & Computer Education Department. The students had the necessary knowledge and skills in hypermedia development, and they did not get any orientation or training in hypermedia development area. Therefore one needs to be cautious in generalizing the results of this study. Despite these limitations, this study provides valuable contribution with regard to relationship between knowledge acquisition and retention, and use of hypermedia as a cognitive tool in teacher education institutions.

In further studies, in addition to the knowledge acquisition and retention, investigations to assess other skills and gains of the students from use of hypermedia as a cognitive tool can be suggested. It is recommended that to be able to see the contribution of hypermedia for learning as a cognitive tool, further research studies in different subject area, with different learners groups, and with different time periods are needed.

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