Different modes of digital learning object use in school settings: Do we design for individual or collaborative learning?

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ABSTRACT

The aim of the studies reported in this paper is to gain classroom based empirical evidence on the learning effectiveness of learning objects used in two types of study settings: Collaborative and individual. A total of 127 seventh and ninth grade students participated in the experiments. They were assigned into one of the study modes and worked with one of the four learning objects. The pretest and post test measures and observation data showed that though the learning objects were primarily developed for individual use, they may also help students working in peers. The comparison among different study modes did not strongly favor any of the study modes. However, the study provided evidence that using the learning objects in different modes is possible and designing and developing learning objects for the use of multiple modes is crucial. Implications on collaborative learning objects are discussed.

Keywords: Learning object, Collaboration object, Learning environment, Instructional design

INTRODUCTION

Many technology based materials only distribute content presentation with highly colorful, maybe animated, graphical representations. In widely available courseware sets, learning facilities for exploration, and virtual manipulatives for provoking thinking and reflection are still limited. With the increased use of Internet tools, chat, forums and discussion boards have become more common than those sense making and student centered elaborative tools. Also, the use of digital technology based communication tools unfortunately have become sociability tools rather than social learning tools. In recent years, technological advancements together with instructional design have contributed to the development of new educational materials to improve student learning. Though with the introduction and industrial standards of learning objects (LOs), technology based learning materials have become more and more individualistic, ease of access and ease of use of communication tools have widened the gate for collaborative learning materials. The streams of LOs and collaborative learning tools seem to have travelled different routes. However, as learning is an individual process, no matter in what educational setting it takes place, whether collaborative or self-study, all available learning materials including LOs should be employed in any educational setting.

Theoretical analyses of classroom group work may be traced back to Dewey's assertion (1916) that students should be stimulated to work as participants of communities, actively pursuing interests in cooperation with others. Later Piaget (1932) assumed that cooperation provides the social context where pupils would be motivated to organize existing thoughts with alternatives. Vygotsky (1978) further stressed the prominence of learning within a social context. His argument on the social dimension in individuals' construction of knowledge and meaning led to the notion that collaboration with peers assists learners reaching new knowledge. In contrast to individual learning, collaborative learning was defined as (Pfister, 2005, p.40) "a learning method involving a group of learners who exchange knowledge and/or solve problems together and interdependently under a common learning goal". In such learning process, knowledge will be elaborated when learners need to (1) make their knowledge, misconceptions, and lack of knowledge explicit (King, 1999; Pfister, 2005), and (2) negotiate knowledge through arguments and justifications with other participants during a discourse (Anderson, Bruhn, Grasel, & Mandl, 2001; Driver, Newton, & Osborne, 2000). More elaborated knowledge via collaborative activities can lead to shared understanding, deep

learning, critical thinking, and long term retention of the learned material (Fisher Bruhn, Grasel, & Mandl, 2002; Johnson, & Johnson, 1994; Porcaro, 2011).

COLLABORATIVE LEARNING RESEARCH and LOs

The studies on collaborative learning have lead to controversial results with respect to its effectiveness. Though a number of studies on collaborative learning have revealed promising improvement in learning outcomes for both group and individual basis, the empirical research has also shown disadvantages of collaborative settings. For example, evidence was provided on second grade students' use of collaborative learning, particularly in that the technological network improves communication, interactivity, negotiation and coordination between members of collaborative learning groups (Infante, Hidalgo, Nussbaum, Alarcón, & Gottlieb, 2009). In another study where secondary school students used wikis for a collaborative work; the study reported learning gains and concluded that rather than the medium, "consideration for the authenticity of the task, the role of the teacher, and the nature and form of assessment will be essential if a move to more collaborative practices in the classroom is desired" (p. 106).

There are studies (Anderson et al., 2001; Pfister, 2005) providing evidence in terms of drawbacks of collaborative learning, for example, it was reported that (Ding, 2009), in computer supported collaborative learning (CSCL), one student was sometimes put at a disadvantage while the group succeeded. Even if a consensus was reached, there was always the possibility that one student might not have cognitive involvement, hence poor learning may result. It was also reported (Edwards, Coddington, & Caterina, 2009) that "some students work in a more consensual fashion than the others, debating their plans together before acting. Some tended to act without discussing their ideas with their partners, and often took hierarchical, complementary roles rather than egalitarian, cooperative ones" (p. 46). The results of the research studies in CSCL are hard to compare, because they differ from each other in terms of properties. A detailed analysis of research on different collaborative learning environments is beyond the scope of this paper.

Bringing learners together or placing them in groups does not guarantee collaboration (Fisher et al., 2002, Tolmie, Topping, Christie, Donaldson, Howe, Jessiman, Livingston & Thurston, 2009); however "a complex of simultaneously applied instructional approaches, each reinforcing and complementing the other can enhance collaborative learning and social interaction among group members" (Kirschner & Kreijns, 2005; p. 172). Many researchers relate the notion, design and implementation of LOs to e-learning (Varlamis & Apostolakis, 2006; Cohen & Nycz, 2006) where students use the provided learning materials mostly on their own and seldom collaboratively (Ada, 2009; Sabau, 2007). Some of the standardization efforts have made LOs an approach to learning and teaching. The LO approach became popular due to its features such as interoperability, durability, scalability, adaptability, reusability, flexibility and cost-effectiveness. For that approach, the sharable content object reference model (SCORM), aims to provide access to materials tailored to individual needs, delivered cost-effectively anytime and anywhere. All elements in SCORM are accompanied by meta-data defined according to a standard called learning object metadata. These standards and SCORM framework neglects the social interaction principle of knowledge integration (Akpınar & Şimsek, 2007). Further, there is no group in SCORM, identifying relations between users is not considered, and therefore aggregating individual users' interaction data into a group's interaction data is not possible. Maybe due to weakness in industrial standards of LOs; design, development and evaluation of collaborative use of LOs have not sufficiently been studied.

PURPOSE OF THE STUDY

A few studies have worked on the design, development and evaluation of collaborative LOs. For example; Nurmi and Jaakkola investigated the collaborative use of LOs with only one group where students studied in pairs, and reported that students who collaboratively studied the content with LOs benefitted more from the LOs (Nurmi & Jaakkola, 2006). Many LO repositories contain LOs developed for individual use rather than collaborative use. However, due mainly to the popularity of collaborative learning, many teachers use those LOs, developed for individual learning, as collaborative learning materials.

This study seeks to reveal classroom based evidence that LOs developed for individual use will not be helpful when used in a mode different from their actual design purpose. Hence, the learning effectiveness of LOs, developed for individual use, used in two types of study settings (collaborative and individual) was are investigated. Effectiveness of the LO based learning environments in the two settings are then compared.

METHODOLOGY

This mixed method research incorporated a quasi-experimental design with pre and post tests. The study collected and analyzed quantitative and qualitative data. The sample of the study consisted of 102 7th graders and 25 9th graders, studying in four different state schools located in suburban areas of a metropolitan city. It is important to note that state schools in Turkey differ from private schools in many ways: As the Turkish education system is centralized, and the Ministry of Education decides funding, curriculum, educational policies, textbooks, teacher appointments, and course schedules; classroom activities in all grades are strongly influenced by the curriculum guides of the Ministry. Whereas in private schools, the Ministry has control over governance of the school activities, the schools are free to extend the curriculum, to follow different policies and to adjust its curriculum scheduling. In terms of ICT usage in classrooms, private schools, due to their rich facilities, integrate technology into their activities more often than state schools. There is substantial evidence that Turkish teachers in state schools apply chiefly traditional methods of teaching and learning (Altun, 2006; Kurt, 2010).

One group of 7th graders studied a module on unit of Pressure/Buoyant force came from two classrooms, taught by the same teacher, at the same school. The two other learning units for the 7th graders, taught by different teachers, were studied in one classroom each from two different schools. Another set of 9th graders were also from a classroom of a different school. In selecting the sample, it was ensured that the students had not yet studied the content of the LO at that grade. The sample was selected in collaboration with classroom teachers who allowed access to their class activities, and had not covered content of the LO at the time the sample selection procedure started. Therefore, a practical sampling was preferred due to accessibility. The students' allocation to the groups of individual and collaborative study modes were carried out with simple random selection: The LO on Pressure/Buoyant force was to be studied by two classrooms using the same computer laboratory, the first classroom became the individually studying group and the second became the collaboratively studying group. The other LOs were studied by one classroom each, for that reason the number of computer stations at the computer labs helped to allocate students to the study modes, placing first entering students in the collaborative study modes. Table 1 summarizes some properties of the sample, and the LOs studied.

Materials

To compare effectiveness of individual and collaborative usage of LOs, four LOs for four learning units, difficult to learn, were selected from a LO repository. Three of the LOs were on seventh grade Science, Pressure/Buoyant force; Work and energy, and Electricity in daily life,

and one was on ninth grade Geography, Map scales. The LOs with simulation characteristics were selected. The tasks in the LOs required students to study a given problem within the simulated story of the LO, and answer the given contextualized problem by using computational facilities of the particular LO. In addition, two achievement tests for each of the learning units were developed; one as a pre-test to measure how much students know about the learning content, another as a post-test to measure how much students learnt about the content. The two tests for the units targeted the same instructional objectives, had the same number of multiple choice items, however the items were different. Number of items in the tests is given in Table 1.

Procedure

The experimental studies took place in the computer labs of the schools. The purpose of the studies was explained as "helping the students to learn the given learning task by using the presented LO settings" to all participants. Each group was then given the pretest lasting 10-20 minutes for four different learning units. Following the pretest, the participants were asked to run the courseware. The procedures to control and use the facilities of the courseware settings were explained to them which took 4-8 minutes. The students who were going to study in a collaborative mode, the two students working together in front of a computer, were instructed to "do the activities in the courseware setting together: Study the materials, then share with your partner what you understood and what your opinion is, discuss with the partner and finally produce an agreement. All decisions you have to make in using the system and in your study in the system must be agreed on, even all mouse actions and any data entry to the system must be based upon agreement with the partner". Further, in order to make the engagement time similar for the two learning groups, the students who were going to study in an individual mode were instructed to "explain yourself what you did understand and why you made the particular decision at a given task of the LO".

Table 1: Some properties of the sample, and the LO studied

Learning object domain	Learning object on	Grade	Age	Number of activity	Size of individually studying group	Size of collaboratively studying group	Number of classroom
Science	Pressure/Buoyant force	7	13	10	25	28	2
Science	Work and energy	7	13	14	7	14	1
Science	Electricity in daily life	7	13	16	12	16	1
Geography	Map scales	9	15	10	15	10	1

During the students' activities, the researcher took notes on students' performances regarding usage of the system. The notes included information about how the students handled the screen objects, and how they navigated the facilities. The dynamics of pair interaction regarding learning was conversational in nature, and could not be addressed in the notes. The researcher's present in the classroom continuously reminded students that both members of a pair is responsible for task solutions and they have to agree on all their actions. Hence a consensus agreement would be built. Throughout the activities, the researcher walked around the classroom and closely monitored the pairs' activities to make sure that no one was dominating the peer interaction; those who didn't consider their peer's suggestions were warned to do so. The researcher managed to monitor these activities due to the small number of pairs (at most eight pairs) in one lab session. To allow students to try out more

ideas than the agreed ones in the LO settings, they were asked to do the following trial of an agreed idea for the task. Because the essence of collaboration among the paired peers is the construction of shared meanings for conversations, concepts, and experiences, thinking should be distributed among members of the pairs. In collaborative learning, learner interaction includes shared as well as individual responsibility, and identification of their role in the learning task (Ewing & Miller, 2002). For that reason, in the studies, each member of a pair first agreed on who would control the manipulation devices, mouse and keyboard (in fact in some pair groups, one of the students controlled the mouse while the other controlled the keyboard), then they read the presented task and thought about how to do it in the LO. They were asked to share with each other what action they would take, and what particular tools of the LO they would use. In this way, each member of the pair worked on the same aspect of the problem at the same time, sharing cognitive responsibility for the task at hand.

After the learning activities with the LOs ended, each group then received their post-test lasting 8-20 minutes for four different learning units. In the pre and post tests, all students answered the items on their own. In addition, a small usability questionnaire for each LO was given to the students after the study. The questionnaires specific to each LO were developed in the form of a rating scale considered five different topics: system screen, terms and system information, learning to operate the system and system capabilities, and overall user reaction. The scales use a Likert type rating scheme (three-point) based on the suitability of the tool for performing various tasks. The scales consisted of 15-20 items, its key is as follows: Disagree, Neutral, Agree.

Table 2: Descriptive statistics on the pre and post test scores of the groups

Learning object	Study mode	n	Maximum score to be attained	Pretest Mean	Pretest St.dev.	Posttest Mean	Posttest St.dev.	Posttest-Pretest Difference Mean	Posttest-Pretest Difference St.dev.	Cohen's d effect size for Posttest-Pretest
1. Pressure/Buoyant force	II	28	10	4,00	1,96	3,90	1,70	-1,03	2,00	0,24
	I	25		3,82	1,91	3,89	2,10	0,07	2,32	0,05
2. Work and Energy	II	14	10	3,64	1,39	5,07	2,95	1,42	2,71	0,60
	I	7		4,29	2,21	6,57	1,13	2,28	2,29	1,21
3. Electricity in daily life	II	16	16	8,00	1,97	7,19	3,27	-0,81	2,56	2,56
	I	12		7,50	1,93	9,25	2,67	1,75	2,41	0,72
4. Map scales	II	10	10	2,60	1,26	3,40	0,97	0,80	1,75	0,07
	I	15		2,00	1,20	2,60	1,30	0,60	1,96	1,87

I. Individual; II. Collaborative

FINDINGS AND DISCUSSIONS

To examine whether students' two modes of activities within the LOs helped them to learn the contents, a series of statistical analyses were conducted on the pre and post scores. The distribution of scores for each group in the four studies did not show normality. Accordingly, a non-parametric, Mann-Whitney U, test was conducted to verify differences. Before the statistical tests, the data were descriptively examined: In all four applications, the individually and collaboratively studied students' pre and post test scores were similar (see Table 2). Conversely, there are inconsistencies in the students' progress indicated by the pre and post test scores. The individual studied students showed more progress than collaboratively studied students in the LOs for Pressure/Buoyant force and Electricity in daily life, though the difference is not significant. Also, while the effect size for the groups studying LO for Pressure/Buoyant force is negligible, it is remarkable in the LO for Electricity in daily life. In fact, the collaboratively studied groups scored lower means in the post test than in their pre test. Further, while the collaborative studied group in the Geography LO demonstrated a higher mean score in the post test than the pre test, the effect size for the group is negligible. According to Cohen's d effect size measures, in two of the studies, LO for Work and Energy, and LO for Map scales, the instructional effects of the two LOs were exceedingly higher for

the individually studied students than collaboratively studied ones. In only one study, LO for Electricity in daily life, the instructional effect of the LO were higher for the collaboratively studied students than individually studied ones, but nevertheless that effect was negative.

The comparison between the individual and collaborative studied groups' pre and post test scores demonstrated that the groups' pre and post test differences did not significantly differ in three of the studies, with the seventh grade Science LO for Pressure/Buoyant force (Z=-0.28; df=51; p>0.05), Work and energy (Z=-0.79; df=19; p>0.05), and a ninth grade Geography LO, Map scales (Z=-0.14; df=23; p>0.05). However, the groups' pre and post test differences differed in the study with the seventh grade Science LO for Electricity in daily life (Z=-2.29; df=26; p<0.05); indicating that the individually studied students benefitted from the LO more than the collaborative students.

In addition, the researchers' observation of the students' interactions with the LOs and with each other, and the small usability questionnaires given to the students after they study with LOs provided imminent information shedding light on the LO use. It was observed that both groups of students in all four studies asked for help from the human mentor in the lab, rather than first referring to the help facilities of the LOs. Furthermore, the time of the experiments (30-70 minutes) was probably very short for the students to develop a personal or mutual strategic approach to the tasks given. The period was also too short to develop collaborative routines. The groups enjoyed the LOs, and they all finished the tasks of the LOs, nevertheless they wanted to study the LOs again, indicating that they had to spend more time with the LO environments. Though it is not a statistically significant difference, the collaboratively studied students seem to benefit less from the LOs possibly due to the fact that the immediate feedback either in the form of textual explanation or as the visual consequence of the simulations provided by the LOs moderated the effect of social interaction between the pairs. When a delayed form of feedback was preferred instead of the immediate form of feedback, the pairs would have elaborated their decisions more and engage in reflective negotiation more.

Some of the students who worked in pairs advised the researcher to create groups based on students' peer preferences. Future research may extend the study time with larger number of tasks in the LOs, and let learners choose different partners at different stages of the studies. Moreover the observations of this study confirmed the recommendations that group size and group formation are critical. For effective collaboration, maximization of meaningful interaction may be enhanced by organizing pairs or groups heterogeneous in gender, culture, language background and ability (Tolmie et al, 2009). Since pairs in the collaborative groups had to be randomly assigned, the possibility of controlling heterogeneity of members was not possible. Future research should consider group size and heterogeneous group formations. It may be better to assign three students into groups rather than pairing two students; because it was observed in this study that one member of the dyadic pairs sometimes dominates the social and cognitive interaction causing the partner, as well as herself/himself, to engage less in epistemic activities such as describing, predicting, arguing and evaluating.

Though there seems to be statistically insignificant improvement in the collaboratively studied groups' performances in the two LO studies (LO-2 and 4), the results of the statistical analysis of this study do, in general, agree with the studies in Ding (2009) and Edwards et al (1997). As Ding reported that one student was put at a disadvantage while the group (in this study pair group) succeeded. Also, as Edwards et al point out that some students work in a more consensual fashion than the others, debating their plans together before acting; some tend to act without discussing their ideas with their partners. Similarly, in this study, while most pairs in all four studies worked in a consensual manner, some pairs did not discuss both students' ideas: the first idea produced by one of the partners was accepted which caused less cognitive engagement of another member of the pair. The researchers had to often notify those pairs to elaborate and to discuss mutually any opinions before trying out that opinion on the system. This ought to be considered in designing new collaborative version of the LOs, and the LOs for the pairs may have facilities (and requirements) for entering both students'

ideas and sequentially test those presented ideas or entries. Further, this finding also confirms the assertion by Johnson & Johnson (1994) and Tolmie et al (2009) that initial training in group skills may serve to enhance benefits of collaborative learning.

Although some of the pairs controlled the LO interface in turn, the pairs' control of the LO interfaces created problems for some pairs: Both students wanted to control the interfaces, which caused them to waste time and dispute over control of the manipulative device, rather than argue about the content and the issue at hand. This problem was resolved promptly, however by enabling the use of multiple manipulative devices or having available Microsoft Surface like multiple-touch sensing interfaces which may prevent such problems. In fact, a recent study (Infante et al, 2009), employed a multiple-mouse controlled environment from which collaboratively studying learners benefitted more.

It may be easy to suggest that teachers should intervene to regulate the collaboration between students, and the interaction between students and LOs. However, a teacher's intervention in students' work with LOs may impede the internal discourse a student is involved. Also, with the emergence and wide availability of LOs, the design of LOs should still mitigate teachers' preoccupation with concretizing the content for all students, but concentrate on the one in most need. Hence the LO should consider components which can engage students more, and keep records of students' collaborations with others and interactions with the LO facilities with which students can (1) produce arguments and counter-arguments, (2) conduct experiments to support arguments, (3) and compare different arguments and opinions. The current work may have been compromised by the fact that the pre and post tests developed had not been pilot tested, and their reliability was not statistically ensured, but that only an expert opinion validated the tests. The statistical verification of properties of the tests to be used in future studies should be conducted. Hence the test results in this study should be interpreted accordingly. The extension of this work, which is currently being conducted, will fulfill the requirements noted in this study, and implement the emerging Common Cartridge standards: roles of each student of a pair for all activities will be scripted and written down on worksheets. Then the students will be asked and monitored to follow directions of the worksheets attached to LOs. It will employ revised and developed LOs under different study modes in order to examine their effect on long term retention of the learned material.

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