Two Modalities of the Contextualized Courseware in Three Modalities of Classroom Use

Yavuz Akpinar
Bogazici University, ETA-B Blok, 508, Kuzey Kampus, Etiler, Istanbul, Turkey
For correspondence: akpinar@boun.edu.tr;

Özlem Şengül
Bahcesehir University, Besiktas, Turkey
ozlemakgunes@bahcesehir.edu.tr

ABSTRACT
This study investigated the effect of various combinations of contextualization and teacher support on achievement and critical thinking. Two specially-designed sets of courseware were used to teach a unit on logic, one based on a single context and one based on multiple contexts. The participants were 151 9th graders in two vocational high schools. Each student was assigned to one of four groups: The first group used the multiple-context courseware with a teacher tutorial; the second group used the single-context courseware; the third group studied the single context courseware with a teacher tutorial; and the fourth group had a teacher tutorial only. Statistical analysis of two achievement tests on the unit and a critical thinking disposition inventory revealed that, regardless of whether the courseware employed single or multiple contexts, teacher support is beneficial. Findings are discussed in relation to comparable studies reported in the literature. Further research issues are raised in the last section.

Keywords: Contextualization, Single context, Multiple contexts, Learning logic, Critical thinking disposition

INTRODUCTION
Students can manipulate, construct, re-construct and employ knowledge in a concrete or virtually concrete setting by using learning technologies. Instructional designers utilize various tools and techniques to make learning content concrete. One way to concretize is to embed a learning content into a familiar and interesting context. A context is defined as "the whole situation, background or environment relevant to a particular event" (Tessmer & Richey, 1997; p.87). However, context also has other meanings: It can refer to a particular event or phenomenon with phenomenal objects and/or operators; or it can denote a story with a series of connected events in a story that has story objects and operators in one or more places and/or timeframe. It is contexts that generally define and shape one's cognition by relating given domain knowledge to practical use (Snow, 1994). Because cognition and reasoning are both situated (Greeno, 1989), context is an influential element of every learning activity. Students' cognition and their learning are affected by numerous factors, including the classroom climate, learning materials, the task setting, and prior knowledge of the topic. Context may be a single interaction case or a multiple interaction pattern in the social interaction process of learning (Akpınar, 2015). Providing multiple contexts (e.g., simulation, work, street, school, lab) allows for learning experiences in multiple situations, impacting nature of learning. A context, therefore, functions as a cognitive strategy applicable to a study task.

Context is critical in learning because learners derive meaning from their surrounding environment and its components, both through perceptional experiences at different levels and through abstract filters formed by semiotic systems such as language (Boyle, 2002). In the learning process, according to Boyle (2002), there are three layers, namely cognitive, interactional and physiological. Context plays a significant role in the interactional layer of learning, for which reason teachers need to focus on embedding content into a context. Boyle asserts that context has two functions: one is the function of framing learning activities, and the other is the function of connections. Contexts are human made mentors that are thought to help students connect previously learnt information and skills with new ones and resolve their incorrect behavior patterns: One way of connecting new knowledge to prior knowledge is to anchor the situation and event (CTGV, 1992; Marx, Blumenfeld, Krajcik, & Soloway, 1997) so as to involve learners in the domain knowledge that is represented in the situation. "Anchoring events provide students with a common experience from which they can relate new information" (Sherwood, Kinzer, Bransford, & Franks, 1987; p. 419). Empirical research on anchoring events (e.g., CTGV, 1992) demonstrates that rich contextualizing features stimulate memory recall and facilitates the transfer of information to new settings. The second method is to repeatedly engage learners in meaningful problem solving over time (Marx et al., 1997). The present research aimed to (a) clarify effects of single or multiple contextualizations on learning a unit on logic, (b) identify the possible interaction between studying various contextualizations of the learning content and students' critical thinking disposition.

Proposed Benefits of Contextualizing Instruction

Contextualizing instruction focuses students' attention on interrelationships between concepts. Blumenfeld, Marx, Patrick, Krajcik, and Soloway, (1997) point out that "contextualizing instruction helps learners to organize and integrate knowledge by engaging them with ideas from multiple perspectives while pursuing solutions to meaningful problems" (p. 830). In the process of organizing and integrating knowledge, students see how ideas are applied in different situations and construct their own representations of concepts (Marx et al., 1997). Meaningful problem situations also provide opportunities for learners to apply their knowledge and gain perspective in incorporating new knowledge into their existing schema (Edelson, Gordin, & Pea, 1999).

In his framework of meaningful learning, Ausubel (1968) suggested that learning environments should present the learners with some cues that relate to their pre-developed cognitive structure. Context thus becomes an anchoring point for embedding newly learned material in the cognitive structure. Collins, Brown and Newman (1989) employ this approach to context in their cognitive apprenticeship model, and Gagne and Merrill (1990) stress that contextual anchoring in instruction can contribute to effective problem-solving by enhancing meaning in novel tasks and by developing cognitive strategies that are needed in problem solving and transfer of learning. Other researchers have also related context and meaningful learning. Donaldson (1978) conceived context as a meaningful situation that can be a catalyzer in the process of acting and thinking. According to Köhler (1947), one's perception of an organized situation is considered a coherent whole that determines meaning of the constituent elements. Marton and Booth (1997) approached context from a phenomenographic perspective stating that "learning is always based on experiencing a situation and discerning relevant phenomena from that situation" (p. 202). For Vygotsky (1978) activity in a context provides a foundation for meaningful engagement; he goes on to suggest that learning activities should be embedded into cultural settings as meaning-generating contexts. In the Vygotskian school of thought, context is considered in terms of a sociocultural setting, requiring tool-mediated actions, processes, and goals that are to be appreciated in the activity structure. In the framework of activity theory (Kaptelinin & Nardi, 2006), a context is an activity system that can be constituted by activity sets with which students interact in order to accomplish a particular goal. Context can shape human behaviors in a situation and can lead to a unified interpretation which gives meaning to that situation.

Contextualization versus De-contextualization

The contextualization of learning and instruction involves situating learning content in a real-life context, a concrete and constrained fictitious context, or a metaphorical context, aiming to make abstract concepts concrete, to increase comprehension and retention, and to facilitate transfer of learning. Contextualizing instruction is an effective way to increase students' interest, motivation, and achievement (Glynn & Kuballa, 2005; Rennie & Parker, 1996). Data supporting these arguments comes from Cordova and Lepper (1996), for instance, who compared the effects of contextualization and de-contextualization of a mathematics content on students' learning in computer-based learning (CBL) settings; they reported that students who studied an abstract content embedded in a meaningful and appealing fantasy context demonstrated markedly better motivation, involvement, and learning than students who used the same activities in a de-contextualized setting. Similarly, Brenner et al (1997) cast math problems in a scenario involving a hypothetical trade company to teach functions; participants in this intervention developed greater gains in problem representation than the control group. However, the control group developed better knowledge of symbol manipulation because they had focused squarely on symbolic representations, while the experimental group was more involved more in understanding and concrete representation. There are known caveats, e.g., developing a sound understanding of the domain in multiple representations is key to learning.

In a more comprehensive three-year study in college mathematics (Shore, Shore & Boggs, 2004) students who received contextualized instruction in the first two years obtained better math scores than students receiving traditional math instruction. However, the two groups' math scores were not different in the third year. This unexpected result was explained in terms of the fact that the contextualized problems in the third year were found particularly difficult by underprepared students. Given these seemingly contradictory findings, a firm conclusion about the practical use of contextualization/de-contextualization could not be drawn.

Earlier, psychology researchers also analyzed how changes in context affect learning and memory. A well-known study on the effect of context in learning was conducted with deep-sea divers who were asked to learn and recall word lists under water and on land. The experiment showed that altering the context between encoding and retrieval reduced the divers' ability to recall learned words (Godden & Baddeley, 1975). Different types of contextual cues may have different effects on encoding and recall. For example, music, light, background colors/patterns (Dallett & Wilcox, 1968; Smith, Glenberg, & Bjork, 1978), mood (Jamison, 2009), and study environment (Smith, 1985) are all contextual cues. The ability of an individual to recall the source of an episode will affect the likelihood of that memory being remembered (Johnson, Hashtroudi, & Lindsay, 1993). Recall is better when the environment of the original learning is reinstated. Reinstatement of context can be accomplished either by physically returning to the encoding environment or by mentally visualizing that environment (Smith & Vela, 2001). Moreover, functional magnetic resonance imaging (fMRI) studies have indicated the role of context-dependent memory. Kalisch, Korenfeld, Stephan, Weiskopf, and Dolan (2000), for instance, determined that context-dependent extinction memory is associated with activation in hippocampus and ventromedial prefrontal cortex, which mainly orchestrate thoughts and actions in accordance with internal goals. Wagner, Desmond, Glover, and Gabrieli (2000) showed that activation of the right prefrontal cortex depends on contextual information. In a contextual cueing task, Manelis and Reder (2012) used a combination of fMRI and eye-tracking technology to explore the mechanisms that facilitate the visual search for repeated spatial configurations. They concluded that "context repetition facilitates visual search through chunk formation that reduces the number of effective distractors that have to be processed during the search" (p. 530). Context repetition allows for continuous and effective chunk updating; it therefore, influences procedural learning. In most of these studies, contextual cues were shown to be unrelated to the application of the learning content in a given contextual task, but rather, they were related to the conditions of the context.

Learning in a Single- versus Multiple-Context Learning Environment

In the teaching of concepts, using multiple contexts can increase the possibility that the concept will be appropriately applied to new circumstances. In her classic experiments, Nitsch (1977) found that, when instruction used a single context, students were able to identify additional examples in the same context; while students who received instruction using multiple had difficulty applying it in new contexts. Once they learnt it, however, they were successful in applying it in new situations. Nitsch therefore suggested using a hybrid strategy where students would initially be given examples in a single context, and then in multiple contexts.

Tessmer and Richey (1997), on the other hand, recommend a multi-contextual emphasis of instruction for facilitating transfer, and suggested emphasizing elements of the immediate environment for the near transfer. Clark and Voogel (1995) took these ideas further and suggested partial decontextualization claiming that "the extent of transfer is determined, in part, by the amount of decontextualization achieved during instruction" (p. 11). Rayner (2005) supports this position and argues that limiting learning content to a specific context will prevent students from being able to generalize their knowledge outside the learning context. Moreover, Bassok (1997) provides evidence that context-based instruction in math suppresses transfer of knowledge to other contexts. Taasoobsuirazi and Carr, (2008) maintain that there is insufficient research exploring whether students are better able to transfer to different real world problems what they learn in a contextualized setting versus what they learn in conventional instruction.

Contextualization of Content in E-learning

Once context is considered for the design of learning environment, the questions of how many contexts and which contexts should be selected are critical. In conventional classrooms, when multiple contexts are used, learning content may be reflected and conveyed in a shallow manner in different contexts. Because it impractical to conduct in-depth investigation in all contexts due to class scheduling, different parts of the content are generally examined in different contexts. A single context lesson has the advantage of providing more in-depth investigation opportunities and tools with which students can manipulate content elements under varying conditions (see Figure 1). Such interaction can help relate content elements to existing mental structures and clarify reference points to new mental structures to be constructed by students. In a learning environment with a single context, students are expected to develop a sound understanding of the concept, and sufficiently generalizable knowledge, and to improve their metacognitive and problem solving skills, all of which, to a certain extent, require de-contextualization of knowledge developed. Then when a content-related problem is presented in a new context, students will first recall the contextual framework, identify similarities and differences between that framework and the problem of the context, and find a solution. If the two contexts have common properties, finding and applying a solution path is easy. However, if there are a few common properties, a de-contextualized conceptual framework (developed during initial learning) is said to help find a solution path. Some researchers (Bjork & Richardson-Klavhen, 1989; Bransford, Brown, & Cocking, 2000; Gick & Holyoak, 1983; Johnson, Reisslein, & Reisslein, 2014; Williams, 1992) assert that single contextualization may not suffice to develop a firm conceptual framework and sound problem-solving knowledge to deal with problems, either in context that are different from the learning context or in a de-contextualized state. Hence, for the purpose of increasing students' experiences and possibility of finding common properties in later problem states, embedding contents in contexts, whether single or multiple, may not be sufficient. Gradual de-contextualization of content is also required. Studies on the use of single and multiple contexts in learning environments have yielded divergent outcomes, and there is a shortage of in-depth studies on the amount of learning in CBL settings with a single context compared to those with multiple contexts.

Computer technology enables authoring different task sequences of a learning content in a single or multiple contexts. The task sequence may contain de-contextualized tasks to which the students may access after successfully completing certain number of contextualized tasks. Such shift in the sequence of tasks may be accomplished through selecting a proper story to contextualize, designing and sequencing events (tailored as tasks for students) and objects and operators of the events, then creating tasks with objects and operators which require the use of conceptual as well as abstract mathematical model of events (Akpınar, Şengül & Kutbay, 2015; Akgüneş, 2016). The number of abstractly represented variable in a task would initially be small and will later be increased. Another way of gradual shift may be achieved as that some variables of a particular operator of a task may be executed with concrete representations of variables, but some other variables of the same operator may be executed with symbolic representation of variables. For example, in high school mathematics, logic is a learning unit which could be contextualized by using an intriguing story like a journey to the space. In this context a simulation and a modelling environment may be designed. In such an environment, students' task may be to manage a space vehicle, and repair broken parts of the vehicle (objects) by the help of tools provided in the vehicle connected to variables of the logic unit (operators). Students may code the sockets of the vehicle by using logical propositions, and test out those sockets within the vehicle (operators). The logical propositions, reflected in the tasks given to the students, will be about different states of the vehicle (such as position, distance to somewhere), and they will be transformed to the socket with the abstract language of the learning unit (p, q, r, l, 0, V and =>). Specific operators (machines) for coding sockets will be used and coding tasks will be ordered from simple and concrete to more complex and abstract. Those tasks will have variety to provide opportunities for demonstrating all possible and different logical statements and logic codes. For this purpose, states of the vehicle will also be changed and simulated. The operators of the environment, designed as integral part of the vehicle, will serve as modelling tools. Further, in order to get students to experience and develop the qualitative communication language of the logic unit, seamless tasks will be given to students. Those tasks require sending messages from the vehicle to the central base on Earth. This scenario formed the single context courseware in this research.

Critical Thinking Disposition and Learning in Context Based Settings

One important objective of schooling is to get students to develop abilities to think critically, and to make rational decisions about what to do or what to believe (Ennis, 1989). Critical thinking (CT) is necessary for both daily-life and professional-life decisions: One has to develop CT skills to understand the surrounding environment and ideas received, and also for meaningful learning in classrooms. One might use the following CT skills in judging the strength of arguments (Beyer, 1988); (i) distinguishing between verifiable facts and value claims, and relevant from irrelevant information, (ii) determining the factual accuracy of a statement, and credibility of an information source, (iii) identifying ambiguous claims, unstated assumptions and logical fallacies, (iv) detecting bias and logical inconsistencies in a line of reasoning. A critical thinking disposition (CTD) is "the consistent internal motivation to engage problems and make decisions through the use of CT" (Facione Sánchez, Facione, & Gainen, 1995; p.3). Research studies (e.g. Bell & Moon, 2015; Morris & Chikwa, 2014) demonstrated that students with greater CT dispositions achieve better learning outcomes in e-learning, take different perspectives into consideration, and become less dependent on teachers and textbooks. Further, Hirayama and Kusumi (2004) found that CTD is important to conclude correctly from contrary evidences and to learn because critical thinkers search for adequate evaluation of the evidence in a given case even when a cognitive tool such as decontextualized instructions is absent (Macpherson & Stanovich, 2007; Neuman, Weinstock, & Glasner, 2006). Once students develop and use sufficient CT skills and a culture of CTD, learning a particular content in a single context setting may be satisfactory since those with high CTD may be able to combine concrete set of knowledge acquired in a single context setting and CT skills to handle problems of new situations. Though many researchers (e.g., Halpern, 1998; Zohar, Weinberger, & Tamir, 1994) suggest providing multiple opportunities to practice strategies in tasks that cut across multiple domains and contexts, hence, the role of embedding a learning content into a single or multiple context in a learning setting is worth examining.

RESEARCH PROBLEMS

This study aimed to shed light on the effects of single and multiple contextualization of content, prior knowledge about the content and CTD on learners' development of knowledge. In line with the prerequisites, our research questions are that:

- Is there a significant difference between learning gain scores of students studying with a single context courseware and the one studying with a multiple context courseware?

- To what extend do prior knowledge about the learning unit, CTD and mode of contextualized learning setting together determine learning?

METHOD

Participants

This research, quasi-experimental in nature, conducted a comparative control group design with pre and post-tests (Creswell, 2013). This methodological design was employed to compare the extent of change in groups of 9th graders' conceptual and procedural understanding of logic unit as well as their CTD. The sample, based on accessibility, consisted of volunteered 9th graders from two vocational schools (Technical and Industrial Vocation School) located in the same campus (Table 1). These schools attract students with poor middle-school performance, and chiefly from low and middle income families. The students who were attending to weekend activities in the schools were invited to participate into the study. The study, however, has a limitation: The sample was not a true random selection of students, but rather it was, in effect, a convenience sample. Therefore, the reader must be cautioned against generalizing these results.

Table 1: Participants

Groups	Type of learning environment	n
A	Multiple context courseware with a teacher support	40
B	Single context courseware	41
C	Single context courseware with a teacher support	30
D	Conventional multiple context activities of a teacher (control group)	40
	Total	151

Materials

Two sets of courseware for teaching logic to high school students were designed and developed in collaboration with mathematics teachers. One is for single context based learning (see Figure 1) and the second is for multiple contexts based learning (see Figure 2). Both coursewares were programmed using Adobe Flash. The single context courseware, outlined above in the Contextualization of Content in E-learning section, used only circumstances and events of a journey to one of the planets; while the multiple context courseware required students to study and interpret components of propositions under the given circumstances of contexts as calendar, weather, social sciences, science, communication, and arithmetic. Table 2 shows how the two settings involve students in learning propositions. All of the propositions (and the names) were originally in Turkish, and the translated form is provided in the table.

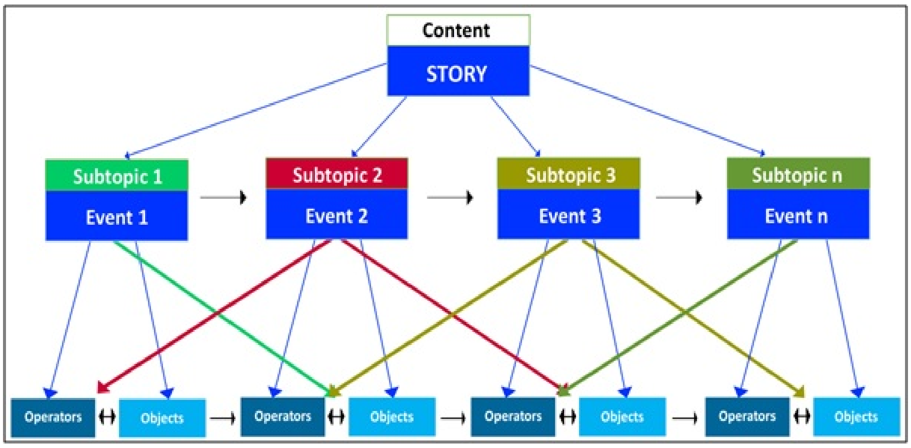

Figure 1: Components of a single context courseware

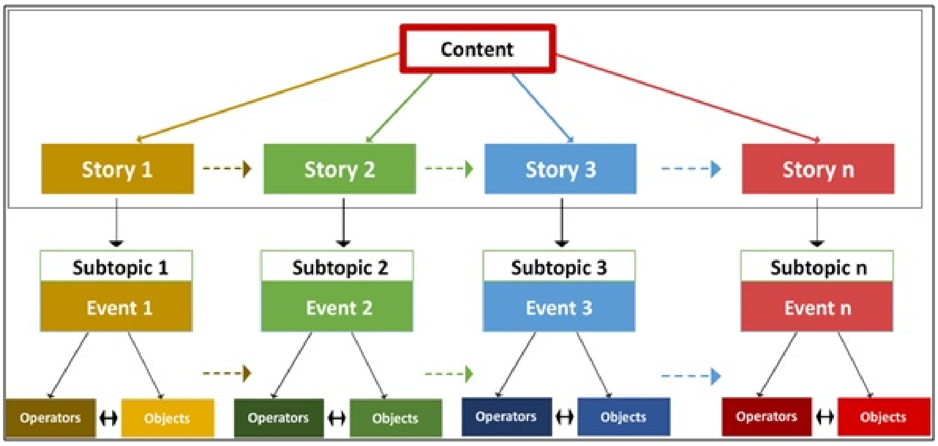

Figure 2: Components of a multiple context courseware

Table 2: Propositions in two different CBL settings

Propositions in single context courseware	Propositions in multiple context courseware
You will monitor and conduct some activities in a space ship to help Astronaut Neil throughout his journey. You will communicate the tasks you conduct and your observations to the base in the world. In your communication, consider the following definition: A proposition is a statement which could be evaluated as correct or incorrect. For example, speed of the space ship is 50 miles per second. Propositions are represented with small letters as p, q and r. • Temperature in the space ship is 22 degree Celsius. • Astronaut Neil keeps the speed constant. • Astronaut Neil received the correct information about his position. • Astronaut Neil repaired the space ship. • Astronaut Neil arrived in the planet. (Note that each of these propositions is produced at different screens.)	You will be asked to conduct some activities about propositions: In your activities, consider the following definition: A proposition is a statement which could be evaluated as correct or incorrect. For example, "Dogs have six legs". Propositions are represented with small letters as p, q and r. Read the following statements, and mark the ones which are propositions: • There are seven days in a week. • 5+8< 12 • The smallest three digit number is 999. • How old are you? • It will rain tomorrow. • Water freezes at zero degrees Celsius. • Girls are as much successful as boys. (Note that each of these propositions is presented at the same screen.)

Data Collection Instruments

To collect data, two identical paper-based achievement tests on the high-school logic unit, one as pre-test and another as post-test, were developed by the researchers and confirmed by four mathematics teachers. Corresponding to the two courseware sets, the tests focused on learning objectives about propositional logic and compound proposition of the unit. Each test contained 15 multiple-choice items with four alternatives: While nine items measured conceptual knowledge, six items measured procedural knowledge of the unit. The second data collection tool is the scale for CTD; this is a five-point Likert type scale with 30 items adapted by Akbıyık (2002) from Ennis (1985).

Design

Prior to the experiment, the participants' CTD and prior knowledge in logic unit were measured. The participants were randomly assigned to one of four between-subjects conditions in such a way that each condition had a similar number of participants; however, Group C consisted of 30 students since 8 students out of 38 in this group missed the post-test session. The experimental groups studied two modalities of the contextualised courseware in three modalities: Group A studied the multiple context courseware with a teacher support, Group B studied the single context courseware without a teacher support, and Group C studied the single context courseware with a teacher support. The support modalities were conducted in a way that students study the courseware on their own first in a lesson hour, then the next day the same teacher held a problem solving session where she exemplified the content and solves questions in different contexts, also the teacher asked two students in A and C groups to exemplify to each subtopic of the unit and provided feedback to their responses. During students' study with the courseware sets in the first three modalities, the teacher was available to answer any questions posed by the students. Nevertheless, the control group students studied the same content with the same teacher without using any courseware; the teacher conducted a conventional instruction describing, discussing and exemplifying the content and solving questions in multiple contexts in two sessions. Following the instructional activities, the scale for CTD and the logic post-test were administered to the students a week later.

RESULTS

To establish equivalence of the level of students' prior knowledge in logic unit in the four instructional conditions prior to attending the experiments, an analysis of variance was run on the pre-test scores. The resulting nonsignificant F (df=3/147) of 1,064 indicated that four groups were initially equivalent on prior knowledge in the unit. The descriptive statistics on the groups' pre-test, post-test and achievement scores in Logic unit are given in Table 3.

Table 3: The groups' pretest, posttest and achievement scores in Logic unit

Groups	n	Pre-test		Post-test		Achievement (Post-pretest)	
		M	SD	M	SD	M	SD
A	40	3,250	1,514	6,450	2,601	3,200	2,802
B	41	3,439	1,500	4,073	1,941	,634	2,527
C	30	3,167	1,641	6,100	2,040	2,933	2,242
D	40	2,825	1,677	3,325	2,055	,500	2,470

Further ANOVA tests revealed that the four groups' achievement of conceptual [F(3, 147)=11,452; p=0,0001], procedural [F(3, 147)=3,934; p=0,010] and combined knowledge [F(3, 147)= 12,415; p=0,0001] of the Logic unit differed significantly. The post hoc Bonferroni tests (Bonferroni correction alpha=0.0125) for achievement of conceptual, procedural and combined knowledge of the groups showed that;

(i) achievement of conceptual knowledge of Logic unit of the group A (M=2,3; SD=2,053) is significantly higher than the group B (M=,487; SD=2,001) and the group D (M=,550; SD=2,074); the group C (M=2,7; SD=2,135) significantly outperformed the group B (M=,487; SD=2,001) and the group D (M=,550; SD=2,074),

(ii) achievement of procedural knowledge of Logic unit of the group A (M=0,95; SD=1,632) is significantly higher than the group D (M=0,00; SD=1,358), whereas the groups studying with one or more context software performed similar achievement.

(iii) achievement of combined knowledge of Logic unit of the group A (M=3,2; SD=2,802) is significantly higher than the group B (M=,634; SD=2,527) and the group D (M=,500; SD=2,470), whereas the group C (M=2,933; SD=2,242) outperformed the group B (M=,634; SD=2,527) and the group D (M=,500; SD=2,470).

Covariate effect of prior knowledge, prior CTD and treatments on learning

A univariate general linear model with three variables (2x2x4) ANOVA test revealed the degree of interaction between students' prior knowledge in logic (with two categories of small and moderate), students' CTD (with two categories of small and moderate) and the type of contextualized learning environment (with four categories) to predict learning logic (Table 4). Students' prior knowledge in logic, [F(1)= 17,997; p=0,0001)] and the type of contextualized learning environment [F(3)= 11,315; p=0,0001)] do separately influence learning logic; effect size coefficients (Partial eta squared) for prior knowledge in logic (0,118) and the type of contextualized learning environment (0,201) showed a moderate effect on learning logic. The covariate effect of students' prior knowledge in the unit and prior CTD together F(1)= 5,157; p=0,025)] is meaningful, but small (%4). However, the covariate effect of the type of learning environment and students' prior CTD on logic learning is not meaningful [F(3)= 0,252; p=0,860)]. Overall covariate effect of the three variables on learning logic is also moderate (Adjusted R Squared = ,321; alpha = ,05)], and they explain 32% of the variation in learning logic.

Table 4: A univariate general linear model with three variables

Source	Tip III Sum of Squares	df	Mean of Squares	F	Sig.	Partial Eta Squared	Non centrality Parameter	Statistical power
Corrected Model	461,172[a]	15	30,745	5,731	,000	,389[a]	85,964	1,000
Intercept	251,284	1	251,284	46,840	,000	,258	46,840	1,000
Learning environment (LE)	182,105	3	60,702	11,315	,000	,201	33,945	,999
Prior knowledge (PK)	96,548	1	96,548	17,997	,000	,118	17,997	,988
Prior CTD	,049	1	,049	,009	,924	,000	,009	,051
LE x PK	12,868	3	4,289	,800	,496	,017	2,399	,219
LE x Prior CTD	4,056	3	1,352	,252	,860	,006	,756	,097
PK x Prior CTD	27,668	1	27,668	5,157	,025	,037	5,157	,616
LE x PK x Prior CTD	4,621	3	1,540	,287	,835	,006	,861	,104
Error	724,232	135	5,365					
Sum	1640,000	151						
Corrected Sum	1185,404	150						

a. R Squared = ,389 (Adjusted R Squared = ,321); alpha = ,05

Table 5: The groups' scores of pre-test, post-test and progress in CTD

Groups	n	CTD pre-test		CTD post-test		CTD progress		Hedge's g effect size
		M	*SD*	*M*	*SD*	*M*	*SD*	
A	40	93,475	19,098	98,500	15,165	5,025	14,260	0,29
B	41	96,000	9,102	97,488	11,792	1,487	12,147	0,10
C	30	104,133	14,412	107,233	12,065	3,100	8,637	0,23
D	40	89,825	10,007	98,000	12,798	8,175	15,068	0,81

The groups' CTD pretest, CTD posttest and CTD progress (difference between CTD posttest and CTD pretest scores) (see Table 5) were estimated, and an ANOVA test [F(3,147)=1,936; p=0,126] revealed that the groups' CTD progress did not significantly differ. According to Hedge's g effect size coefficients, all the groups' CTD scores increased after the treatments; However, CTD scores of the student group (D) who studied the unit with a teacher only increased the most (g=0,81) and CTD scores of the student group (A) who studied the unit with a multiple context courseware and a teacher increased the second (g=0,29) compared to other groups. This observation was confirmed by paired sample *t* tests (Table 6) conducted for the pre and post CTD scores of each group revealed that the increase in both CTD scores of the student group (D) who studied the unit with a teacher only (Mpre=89,825, SD=10,007; Mpost=98,00, SD=12,798; t(39)=3,431, p=0,001), and of the student group (A) who studied the unit with a multiple context courseware and a teacher (Mpre=93,475, SD =19,098; Mpost = 98,50, SD =15,165; t(39)=2,229, p=0,032) were statistically meaningful.

Table 6: Paired samples t tests for the groups' CTD scores

	M	SD	SEM	t	df	p
A_CTD_Post - A_CTD_Pre	5,025	14,260	2,254	2,229	39	,032
B_CTD_Post - B_CTD_Pre	1,487	12,147	1,897	,784	40	,438
C_CTD_Post - C_CTD_Pre	3,100	8,635	1,576	1,966	29	,059
D_CTD_Post - D_CTD_Pre	8,175	15,068	2,382	3,431	39	,001

DISCUSSION AND CONCLUSIONS

The study explored the design and implementation of a single and multiple context use with or without a teacher's support in computer based environments for the learning unit, logic. The results of the present study indicated that embedding a learning unit into a single or multiple contexts positively affects students' learning of both conceptual and procedural knowledge of the study unit only when these modes of contextualization are supported with a human teacher's additional activities of practicing in different contexts and decontextualization. In terms of achievement in conceptual knowledge in the unit, the group who studied the unit with a single context courseware with a teacher's activities outperformed both the group who studied the unit with merely a single context courseware and the group who studied the unit with only a teacher. Similarly, the group who studied the unit with a multiple context courseware with a teacher's additional activities outperformed both the group who studied the unit with merely a single context courseware and the group who studied the unit with only a teacher. However, the group that studied in a single context courseware with a teacher support, and the group that studied in a multiple context courseware with teacher support had similar achievement in conceptual knowledge in the unit. The mode of studying the unit in a single context courseware only generated a similar outcome as the one in only teacher activities.

In terms of achievement in procedural knowledge of the unit, the group who studied the unit with a multiple context courseware with a teacher's additional activities outperformed the group that studied the unit with only a teacher. Additionally, achievement in procedural knowledge of the unit of the groups who studied the unit with merely a single or a multiple context courseware with or without a teacher's additional activities was identical. However, performance of the teacher only group was the least among all groups.

When two types of knowledge, conceptual and procedural, were considered together, the same result as the one in achievement of conceptual knowledge was obtained. These findings have similarities and differences to the earlier literature, though, additional contextual practice examples and decontextualization activities conducted by a teacher seem to make the current study different from the earlier works reported in the literature, To a large extent, it confirms the findings obtained in the study by Cordova and Lepper (1996) and by Nistch (1977) that computer based contextualization settings help learning, but the amount of learning increases when those contextualization modes are supported by a teacher's additional activities of practising further in different contexts and decontextualization. Also, it has different findings from the studies by Bassok (1997) and Brenner et al (1997) that computer based contextualization settings help learning more than the teachers' contextualisation and decontextualization; in this study both the single and multiple context groups with or without teacher support helped learning more than just a teacher support mode. In addition, this study, unlike the one by Shore et al (1997), showed that the students in computer based contextualization settings found the activities easy. To compare the results with those of the ones involving the fMRI based studies (e.g., Manelis & Reder, 2012), context repetition through either multiple context settings or a single context setting with a teacher's practise activities help learning more than the other modes.

Covariate effect of the type of learning environment, students' prior knowledge in the learning unit and prior CTD level was found moderate showing that these three variables may explain about one-third of the variability of learning logic; while the type of learning environment alone may explain over one-fifth of the variability of learning logic. The present study also tested whether the type of learning environment and students' CTD interact to affect learning progress; however, covariate effect of the two variables was not significant. It may demonstrate that when learning activities are appropriately contextualised, either by technological facilities or/and by a teacher's activities, the negative effect of lack of students' CTD on learning may possibly be vanished or minimized. Though the intervention studies in all four groups were relatively short, it has to be noted that students in the control group developed more CTD than the ones in the experimental groups. This is perhaps due to the amount of student-teacher interaction which was, in nature, more in the control group than the one in all three experimental groups. Further, improvement of CTD of the students in the multiple context environment with a teacher's support and the control group were significant. However, the study failed to confirm the earlier work (Angeli & Valanides, 2009; Bell & Moon, 2015; Morris & Chikwa, 2014) claiming that students with greater CTD achieve better learning outcomes; because all groups' CTD was evenly distributed, and had an average level of CTD, therefore when their CTD scores were categorized, we used only two categories as low and moderate CTD in statistical analysis. Though CTD is a necessary component in learning (Macpherson & Stanovich, 2007), the covariate analysis showed that the type of learning environment is more dominant in learning than students' CTD.

Learning a particular content in a single context setting is not satisfactory; teachers' activities which combine a concrete set of knowledge acquired in a single context setting and problems of new situations is required. The study confirmed the assertions providing multiple opportunities to practice strategies in tasks that cut across varying contexts (Halpern, 1998; Zohar et al.1994) is necessary for better learning. In this study, both the group studied only with a single context courseware, and the group studied only with a teacher's contextualization and decontextualized activities could not learn as much as the other two groups receiving a teacher's practice example in different contexts and finally decontextualized examples.

The study has some implications for the design of online and blended learning environments: First, despite the rapid growth of K-12 online and blended education (e.g., flipped classroom) how best to support K-12 learners are not clear. This study suggests that interactive courseware to be designed for K-12 learners should consider placing learning content into contexts, but still consider a human teacher's activities of enriching contextual cues and decontextualization for the learning content. Second, courseware providers should continue to provide guidance to students both through computer support and teachers' face-to-face support to improve learning outcomes in different situations. Third, to provide students with different in-depth facilities, courseware developers should consider seamlessly connecting a series of single context settings to form multiple context settings.

LIMITATIONS

Promising and encouraging results were obtained in increasing students' knowledge of logic through context based settings with a teacher's support. The study, however, had some limitations: First, the sample was selected on the basis of accessibility, and from technical and vocational high schools accepting students of poor middle-school performance; further research should consider true-random methods to select students among all type of high schools. Second, the single context courseware utilized a space-journey context in teaching logic; additionally, future research may consider different types of context settings in the same and different learning units. Third, since our findings only relate to 9th grade students who study logic unit at later grades according to their school curriculum, different results could be expected in samples of older year students, who would be more motivated to learn the unit on a timely manner. Fourth, the study should be replicated with settings covering learning units in different domains studied by younger students. Fifth, further research should investigate covariate effects of those independent variables of the study with much larger samples in order to increase statistical power of the general linear model analysis. Finally, fMRI technology may be used to provide more concrete and direct data on students' interaction with context based settings.

ACKNOWLEDGEMENTS

We thank teachers and students who participated in the design and implementation studies. This study was supported by Boğaziçi University BAP, grant #: 8384.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

Akbıyık. C. (2002) *Critical Thinking Disposition and Academic Achievement* (Unpublished master thesis). Hacettepe University, Ankara.

Akgüneş, Ö. (2016). Farklı bağlamlardaki bilgisayar destekli uygulamaların lise öğrencilerinin mantık bilgisine ve eleştirel düşünme eğilimlerine etkisi. Yüksek lisans tezi. Bahcesehir Üniversitesi. Istanbul.

Akpınar, Y. (2015). Fall of contextualization in e-learning and separating learning context from others. Paper presented at *IC-ED 2015*. St. Petersburg. Russia.

Akpınar, Y., Sengül, Ö., & Kutbay, E. (2015). Single versus multiple contextualization in e-learning environments. *Proceedings of IAC-TLEL*, pp. 42-46. Budapest, Hungary. Czech Institute of Academic Education.

Bassok, M. (1997). Two types of reliance on correlations between content and structure in reasoning about word problems. In L. English (Ed.) *Mathematical Reasoning* (pp. 221-246). NJ: Erlbaum.

Bell, R., & Moon, L. (2015). The impact of critical thinking disposition on learning using business simulations, *International Journal of Management Education*, 13(2). 119-127.

Beyer, B. K., (1988). *Developing a Thinking Skills Program*. Boston. Allyn and Bacon.

Bjork, R.A., & Richardson-Klavhen, A. (1989). On the puzzling relationship between environment context and human memory. In C. Izawa (ed.), *Current Issues in Cognitive Processes,* (pp. 313-324). NJ: Erlbaum.

Blumenfeld, P.C., Marx, R.W., Patrick, H., Krajcik, J., & Soloway, E. (1997). Teaching for understanding. In: B.J. Biddle, T.L. Good, & I.F. Goodson (Eds.). *International handbook of teachers and teaching* (vol. 2 pp. 819–878). Dordrecht: Kluwer.

Boyle, T. (2002). Towards a theoretical base for educational multimedia design. *Journal of Interactive Media in Education, 2,* Accessed online at http://jime.open.ac.uk/jime/article/view/2002-2.

Bransford, A., Brown, L., & Cocking, R. R., (2000). *How People Learn.* Washington, National Academies Press,

Brenner, M. E., Mayer, R. E., Modeley, B., Brar, T., Duran, R., Reed, B. S., & Webb, D. (1997). Learning by understanding. Role of multiple representations. *American Educational Research Journal*, 34, 663-689.

Clark, R.E. & Voogel, A. (1995). Transfer of training principles for instructional design. *Educational Communication & Technology Journal*, 33, 113-123

Collins, A., Brown, J.S., & Newman, S.E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.) *Knowing, learning, and instruction* (pp. 453-494). NJ: Erlbaum.

Cordova, D. I. & Lepper, M. (1996). Intrinsic motivation and the process of learning. *Journal of Educational Psychology*. 88(4). 715-730.
Cognition and Technology Group at Vanderbilt (1992). The Jasper experiment. *Educational Technology Research & Development*, 40 (1), 65-80.
Creswell, J. W. (2013). *Research Design.* NY. SAGE.
Dallett, K., & Wilcox, S. G., (1968). Contextual stimuli and proactive inhibition. *Journal of Experimental Psychology*. 78, 475-480.
Donaldson, M. (1978). *Children's Minds*. London. Fontana.
Edelson, D., Gordin, D. N., & Pea, R. D., (1999). Addressing challenges of inquiry-based learning through technology and curriculum design. *The Journal of the Learning Sciences*, 8, 391–450.
Ennis, R. H., (1989). Critical thinking and subject specificity. *Educational Researcher,* 18(3), 4-10.
Ennis, R.H., (1985). A logical basis for measuring critical thinking skills. *Educational Leadership*, 43(2), 44-48.
Facione, P.A., Sánchez, C.A, Facione, N.C., & Gainen, J. (1995). The disposition toward critical thinking. *Journal of General Education.* 44(1). 1-25.
Gagné, R. M. & Merrill, D. (1990) Integrative goals for instructional design. *Educational Technology Research and Development*, 38(1), 22-31.
Gick, M., & Holyoak, K. (1983). Scheme induction and analogical transfer, *Cognitive Psychology,* 15(1), 1-38.
Godden, D., & Baddeley, A. (1975). Context dependent memory in two natural environments. *British Journal of Psychology,* 66(3), 325–331.
Greeno, J. (1998). The situativity of knowing, learning, and research. *American Psychologist*, 53(1), 5-26.
Halpern, D. (1998). Teaching CT for transfer across domains: Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist*, 53, 449–455.
Hirayama, R., & Kusumi, T. (2004). Effect of critical thinking disposition on interpretation of controversial issues. *Japanese Journal of Educational Psychology*, 52(2), 186-198.
Jamison, K. J., (2009). *An Unquiet Mind: A Memoir of Moods and Madness*. NY. Random House.
Johnson, A. M., Reisslein, J., & Reisslein, M. (2014). Representation sequencing in computer-based engineering education. *Computers & Education*, 72, 249–261.
Johnson, M.K., Hashtroudi, S., & Lindsay, D.S. (1993). Source monitoring. *Psychological Bulletin,* 114, 3–28.
Kalisch, R., Korenfeld, E., Stephan, K.E., Weiskopf, S.B., & Dolan, R.J. (2006). Context-dependent human extinction memory is mediated by a ventromedial prefrontal and hippocampal network. *The Journal of Neuroscience,* 26(37), 9503–9511.
Kaptelinin, V., & Nardi, B. A. (2006). *Acting with Technology*. MA: MIT Press.
Köhler, W. (1947). *Gestalt Psychology*. NY, Liveright.
Macpherson, R., & Stanovich, K. E. (2007). Cognitive ability, thinking dispositions, and instructional set as predictors of critical thinking. *Learning and Individual Differences*, 17(2), 115–127
Manelis, A., & Reder, L. M. (2012). Procedural learning and associative memory mechanisms contribute to contextual cueing. *Learning & Memory*, *19*(11), 527-534.
Marton, F. & Booth, S. (1997). *Learning and Awareness.* NJ: Erlbaum.
Marx, R. W., Blumenfeld, P.C., Krajcik, J. S., & Soloway, E. (1997). Enacting project based science. *Elementary School Journal*, 97(2), 341-358.
Morris, C. & Chikwa, G. (2014). Screencasts: How effective are they and how do students engage with them? *Active Learning in Higher Education*, 15(1), 25–37.
Neuman, Y., Weinstock, M., & Glasner, A. (2006). The effect of contextual factors on the judgment of informal reasoning fallacies. *Quarterly Journal of Experimental Psychology*, 59(3), 411–425.
Nitsch*, K. E.* (*1977*). *Structuring decontextualized forms of knowledge*. Unpublished doctoral dissertation, Vanderbilt University
Rayner, A. (2005). *Reflections on context based science teaching.* Proceedings of Blended Learning in Science Teaching and Learning Symposium. (pp.169-172). Australia. Uniserve.
Rennie, L. J., & Parker, L.H. (1996). Placing physics problems in real life context. *Australian Science Teachers Journal*, 42, 55-59.
Sherwood, R. D., Kinzer, C. K., Bransford, J. D., & Franks, J. (1987). Some benefits of creating macro-contexts for science instruction. *Journal of Research in Science Teaching*, 24(2), 417–435.
Shore, M., Shore, J., & Boggs, S. (2004). Allied health applications integrated into developmental mathematics using problem based learning. *Mathematics & Computer Education*, 38(2), 183-189
Smith, S. M. (1985). Effects of number of study environments and learning instructions on free-recall clustering and accuracy. *Bulletin of the Psychonomic Society*, 23, 440-442.
Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition,* 6, 342-353
Smith, S., & Vela, E. (2001). Environmental context-dependent memory. *Psychological Bulletin,* 8(2), 203–220.

Snow, R. E. (1994). Abilities in academic tasks. In R. J. Steinberg & R. K: Wrights (Eds.), *Mind in Context* (pp.1-389), NY, Cambridge University Press.
Taasoobsuirazi, G. & Carr, M. (2008). A review and critique of context based physics instruction and assessment. *Educational Research Review*, 3, 155-167.
Tessmer, M. & Richey, R. (1997). The role of context in learning and instructional design. *Educational Technology Research and Development,* 45 (2), 85-115.
Vygotsky, L.S. (1978). *Mind in society: The development of higher mental processes*. MA: Harvard University Press
Wagner, A.D., Desmond, J.E., Glover, G.H., & Gabrieli, J.D.E. (1998). Prefrontal cortex and recognition memory. *Brain,* 121(10), 1985–2002.
Williams, S. M. (1992). Putting case-based instruction into context. *Journal of the Learning Sciences*, 2(4), 367–427.
Zohar, A., Weinberger, Y., & Tamir, P. (1994). The effect of the biology critical thinking project on the development of critical thinking. *Journal of Research in Science Teaching,* 31(2), 183–196.