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Computer Versus Computer and Human Support in an Argumentation-based Science Learning Environment

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Technological advancements have made it possible to design learning environments which support multiple representations, discussions and experimentations. This study designed and developed a web based argumentation environment, Argümantaryum. It provides virtual experimentation with, visually rich multi-representations of contents, video, and simulations upon which students may base their arguments and learn some elementary level science units related to matter. It has also a built-in discussion forum and an instant messaging component both of which contain argumentation sentence-openers. Following the implementation, the system was tested in real classroom settings under different study schemes for different learning units. Results revealed that when students used the system collaboratively under a teacher's guidance, students made progress in terms of both scientific discussion skills and knowledge of the learning units accommodated in the platform. Similar results were also obtained when the same usage scheme was followed for another learning unit. Finally, the report compared performance of the system to a human support only learning environment, and provided a discussion and a set of recommendations on how to further evaluate the platform.[1]

[1] This manuscript is an extension of the paper presented at the WCES2013, Rome, Italy.

INTRODUCTION

Many students start learning science with alternative scientific conceptions or misconceptions. Such unjustified individual viewpoints, though commonly accepted, are likely to lead students to develop new misconceptions (Welmar, 1996). These problems are often observed both in science classrooms as well as domains which include many abstractions. It is also accepted that students have two different viewpoints regarding science (Cadmus, 1990; Tsai & Chou, 2002). One of these is used in formal classroom settings, and the other is used outside the classroom, in daily life. Visualization of scientific facts and laboratory experiments are critical tools to foster students' understanding of science conceptions. According to de Jong, Linn, & Zacharia (2013),"Physical and virtual laboratories can achieve similar objectives such as exploring the nature of science, developing team work abilities, cultivating interest in science, promoting conceptual understanding, and developing inquiry skills" (p. 305). Simulations, modeling, graphical animations and videos of facts can help students to connect new conceptual knowledge to existing mental structures (Ardaç & Ünal, 2008; Escalade, Grabhorn, & Zollman, 1996). Visualization techniques help students both to observe how objects behave and interact, and to develop qualitative understanding of science facts (Cadmus, 1990; Hwang & Esquembre, 2003). For example, multimedia simulations, processing quantitative data and visualization may help students to construct qualitative representations. Such experiences can, in turn, assist students to clarify underlying patterns of visualizations as well as to develop explanations for scientific models and theories. Additionally, observation and manipulation tools may provide students with settings to test hypotheses (McElhaney & Linn, 2012), to connect scientific visualizations to their understanding of complex scientific ideas, and to deal with scientific dilemmas (de Jong et al, 2013). In an attempt to integrate and test different learning materials, this study aims to investigate the effects of use of an argumentation-based learning setting on middle school students' development of scientific discussion skills and learning of selected science units.

ONLINE ENVIRONMENTS FOR LEARNING SCIENCE

With the fast development in networking and web technologies, distributed options for supporting science learning in the web have increased. Hence, models of science learning and teaching through information and communication technology (ICT) tend to vary (For examples, see Jonassen, 1999; Schwart, Linn, Brophy, & Bransford, 1999; Hannafin, Linn, & Oliver, 1999; Perkins & Unger, 1999; Merrill, 1999). In all these projects, chiefly

constructivist learning principles were taken into consideration, and computer representations, guidance and different knowledge resources as well as communication tools are used along with conceptual, operational, and strategic learning supports. Later, some projects developed web based learning environments which mainly consider learning science as development of scientific thinking. One such science learning environment is Knowledge Integration Environment (KIE) by Slotta and Linn (2000). KIE, a derivation of the WISE project (Linn, Clark, & Slotta, 2003), supports the use of Internet resources as evidence to arguments, and solutions and evaluation of the solutions problems. In KIE, while learning science through argumentation, students also receive support on conceptual and strategic issues. Similar to most web-based science learning settings, learning process in KIE starts with a problem statement or a project. Students use available resources under guidance and directions (Chiu & Linn, 2014; McElhaney & Linn, 2012). Furthermore, other research for science learning confirmed design guidelines of the previous studies and many other suggested activity models. For example, Bybee, Taylor, Gardner, Vanscotter, Powell, Westbrook and others (2006) outlined 5E model for learning task design as engagement, exploration, explanation, elaboration, and evaluation. In addition to the 5E model, some studies (e.g. de Jong et al, 2013; Eisenkraft, 2003; Rivet & Krajcik, 2008) also suggested development of authentic tasks.

Online learning settings implement primarily the following characteristics of constructivist learning environments:

- activities and tools are provided to encourage experimentation and reflection;
- learning tasks are realistic and represent complexities of real world in a gradual manner;
- knowledge construction based on experience and prior knowledge is stressed;
- students' own errors provide learning opportunities;
- multiple perspectives and representation of content are presented; and
- collaboration is favored to expose learners to alternative viewpoints and arguments.

Simulations, animations, modelling tools, videos, tutorials, discussion boards and chatting tools are some of the tools to be used in online learning for face-to-face K-12 students; hence, a variety of knowledge and study sources are available and methods of the use of these tools may be very rich. First, affordances of online learning environments for K-12 allow children to have the attention and focus they need from their teachers in order to

learn. Second, they allow students to learn at their own pace: Students may quickly skip material they understand right away, or they may assign more time on challenging topics. Third, students may participate in discussions with their teachers and peers in a classroom discussion board, a platform to express their ideas, especially for shy students without the pressure of having to speak in front of a group. However, the research findings over online learning are controversial. For example, Schollie (2001) compared student performance on end-of-year exams among virtual and traditional school students across the province. The results indicated that scores of virtual school students in the sciences at 6th and 9th grades significantly lagged behind the scores of traditional school students. Later, Sun, Lin, and Yu (2008) evaluated the effectiveness of a Web-based science lab with fifth-graders (n=113) in a quasi-experimental study, Both experimental and control groups received the same number of class hours and conducted manual experiments whilst students in the experimental condition used the Web-based science lab for part of their lab time, and teachers observed student work and corrected errors online, the control group students conducted equivalent experiments using conventional lab equipment. The analysis indicated a remarkable but small effect size of +0.26 favoring the online conditions. A meta-analysis comparing distance and traditional instruction on achievement of both K-12 and higher education students (Cavanaugh, Gillan, Kromrey, Hess, & Blomeyer, 2004) showed that both distance and traditional instruction can have the same effect on students' academic achievement. A more recent analysis (Means, Toyoma, Murhy, Bakia & Jones, 2010) revealed that blends of online and face-to-face instruction, on average, had stronger learning outcomes than face-to-face instruction. However, the same finding was not generalized to K-12 settings due to insufficient experimental and comparative studies with K-12 students in online and traditional environments. It seems that online learning has the potential of redesigning traditional instructional approaches, personalizing instruction, and enhancing the quality of learning experiences.

LEARNING SCIENCE THROUGH ARGUMENTATION

Recently, studies suggested students arguing over concepts and procedures of science learning units to develop better understandings in order to get involved in argumentation help conceptual change in the minds of students (Driver, Newton, & Osborne, 2000; Nussbaum, 2008; Nussbaum & Sinatra, 2003). Whilst considering alternative viewpoints and examining alternative conceptions, students can consolidate their existing scientific knowledge and construct new knowledge based on other ideas (Brown & Champione, 1998). In the process of argumentation, different ideas were

elaborated and debated where students can reflect on their own and others' ideas (Jonassen, Cho, Kwon, Henry & Shen, 2009; Yeh & She, 2010). Scholtz, Braund, Hodges, Koopman, and Lubben (2008) classified overlapping purposes of inclusion of argumentation in school curriculum: (1) to equip students with the skills to critically interrogate every-day claims, and support or refuse evidence for those claims (Zohar & Nemet, 2002), (2) to use argumentation as a learning method of group interaction and discussion to conduct social construction of knowledge and to integrate new evidence into existing cognitive models (Driver et al., 2000; Vygotsky, 1978), (3) to emphasize the nature of scientific knowledge as changeable on the basis of resolving controversial issues through new evidence (Kuhn, 1993), and (4) to practice subject specific modes of scientific discourse (Lemke, 1997). Nevertheless, constructing acceptable and sound arguments is not an easy task, and students need guidance and help to argue (Osborne, Simon, Christodolou, Richardson, & Richardson, 2004; Yeh & She, 2010). Different tools and mechanisms were developed to support argument construction (e.g. Buckingham, Maclean, Bellotti, & Hammond, 1997; Hirch, Saxedi, Cornillon, & Litoselliti, 2003; Karacapilidis & Papadias, 2001; Simon, 2008). For example argumentative sentence-openers were designed to provide students with scaffolding tools to facilitate the development of argumentative dialogue within an interactive dialogue game (Ravenscroft, Wegeriff, & Hartley, 2007). These tools, according to Osborne, Simon, and Erduran (2004), provide students with prompts to construct their arguments in a coherent manner, and these writing frames can be, in turn, used as structure for forming a written argument. Moreover, argument visualization tools such as concept maps, matrices, hierarchy trees, and Vee diagrams have been designed to support argument construction. Though limited, there is some evidence that software argumentation templates provide increased claims about how to solve problems (Cho & Jonassen, 2002; Li & Lim, 2008; Nussbaum & Sinatra, 2003; Saye & Brush, 2002). Thus, students' inquiry skills may be enhanced through scaffolding with argumentation templates.

The argumentation process, in nature, can easily engage a group or groups of students who will express different views, share, discuss, support, evaluate, and conclude arguments and counter-arguments. In such processes, computer supported collaborative learning (CSCL) scenarios have been considered to facilitate egalitarian participation in argumentative discourse while students use additional online resources as well as tools to build and represent arguments (Andriessen, Baker, & Suthers, 2003; Veerman, 2003). However, this assumption on egalitarian participation or engagement of peers was not supported by some other studies (Marttunen, Laurinen, Litoselliti, & Lund, 2005; Meijas, 2007; Weinberger, Stegmann, & Fisher, 2010), because when roles and activities in online settings are distributed, some

learning partners tend to dominate the discussions, which results in blocking either argument construction or engagement in meaningful learning activities. To overcome possible domination of argumentation process by one of the collaborative partners, systems should be designed in a way where each partner can first study individually to select and form his or her own arguments, then study together to debate, re-write, re-form, or modify understandings and arguments.

Students' argumentation has great potential for fostering communication skills to interchange perspectives and meanings (Yeh & She, 2010, p. 589). Yhe and She tested the effectiveness of an online scientific learning program with argumentation: Two groups of 8th graders worked with online scientific learning program with argumentation, and the other two groups worked with the same program without argumentation. The argumentation groups outperformed the other groups on argumentation ability and conceptual change about chemical reactions. This result showed that the essential cognitive component of constructing scientific arguments was assessing alternative viewpoints, filtering evidence, commenting on qualitative representations, and validating scientific claims. Some conditions of students' argument development were also studied. For example, Weinberger et al. (2010) worked with university students writing arguments either indivually or collaboratively, and with or without the support of argumentative scripts. The collaborative learning group outperformed the individually learning group regarding argumentation knowledge if the learning is structured by a script. In another study, Sandoval and Morrison (2003) studied learning of biology in a technology-supported and inquiry-based setting with high school students. An interview with students revealed that the role of an explicit epistemic discourse in developing epistemological understanding is crucial. The same study, however, produced equivocal findings about whether or not engaging in argumentation improves students' epistemic knowledge. In addition to contradictory findings, practical work on conceptual change in science lessons through argumentation is small in number (Weinberger et al., 2010). It has been suggested that (Osborne et al., 2013) engaging in a limited set of scientific practices such as modeling, analyzing, and interpreting data, and constructing explanations are an opportunity to build an understanding of how these practices contribute to the construction of knowledge in science. It is this question that forms the basis of this study.

Human versus Computer Support in Learning

In learning environments, students' engagement with instructional activities is essential. Earlier research (Skinner & Belmont, 1999; Marks, 2000;

Voelkl, 1995) shows that students with caring and supportive interpersonal relationships at school are more engaged academically. Also, teacher support was found to be a positive predictor of both interest and social responsibility goal pursuit in classrooms (Wentzel, 1998). According to Klem and Connell (2004), students need support from people with whom they interact at school in order to take advantage of high curricular expectations. Students need to feel that teachers interact with them. They desire respect and opportunity to make decisions, and they also need a clear sense of structure in which to make those decisions (Lee & Smith, 1999). Teachers may respond to learners' varying questions and needs. They may also adapt instructional settings according to learners' learning progress. However, when it comes to delivering learning materials to individual students according to their individualized learning pace, teachers are not as fast as computers. Teachers lag behind computers in giving immediate feedback to students' actions. Further, teachers need computer-like devices to visualize procedures and to concretize abstractions. In CSCL environments, Kreijns, Kirschner, and Jochems (2003) state that teachers could play a role in stimulating social interaction among group members and/or how the members should socially interact within the group. Meijas (2007) suggests that teachers initially start a discussion that students must continue on their own, which requires the teachers to give up control and avoid dominating the discussions at which many teachers have difficulty shifting from complete control of the classroom to unobtrusive monitoring (Kreijns et al., 2003). Hence, the balance between a teacher and a computer support, and the preference of one of these supports during a particular set of argumentation activities, are critical.

Designing Argumentation Based Science Learning Environments

It is argued that computational tools may enable students to participate in learning at a deeper level, to engage in more reflective action, and to gain greater influence over the course of learning activity in the classroom (Beauchamp & Kennewell, 2010). Ravenscroft, Tait, and Hughes (1998) assert that the more knowledge media are used in curricula, the more learners need instructional guidance and support about integrating them within their wider learning activities. This research aims to empower students with the ability to argue scientifically and by this means change their misconceptions and develop new knowledge of elementary school level science. Under the light of previous studies, the following guiding principles should be considered in designing argumentation based science learning activities enhancing conceptual change:

- to present observation and manipulation tools to students (Osborne et al., 2013).
- to enable individual and/or group work following certain guidance in order to solve authentic tasks, and tools (resources, sharing, modeling, search tools, and support) to help solve them (Yeh & She, 2010).
- to present task regimes to get students to elaborate, debate, and reflect on their own and others' ideas in a mode of possible egalitarian participation in argumentative discourse (Weinberger et al., 2010).
- to provide scaffolding tools such as sentence openers to facilitate the development of argumentative dialogue (Ravenscroft et al., 2007).
- to provide multiple representation tools that may simulate and sustain dialectic argumentation process, and to sufficiently drill argumentation activities (Jonassen & Kim, 2010).

Research Hypotheses

In order to test suggested guidelines of argumentation based learning environments, this study aimed to develop and examine an environment for facilitating science learning through argumentation. The developed system, Argümantaryum, built in accordance with the guidelines presented above, was examined with students and teachers to test the following research hypotheses under different learning scenarios. It is hypothesized that students who use the argumentation-based multimedia science learning environment collaboratively under teacher guidance (computer and human support: CHS) will be

(Ha1) more successful in unit achievement tests and (Ha2) develop better scientific discussion skills than students who use the same platform individually without teacher guidance (computer support only: CS), (Ha3) more successful in unit achievement tests and (Ha4) develop better scientific discussion skills than students who study the same learning units with a teacher within a classroom based setting (human support only: HS).

METHOD

This mixed method research integrated a quasi-experimental control group design with pre and post tests, along with qualitative data collection and quantitative and qualitative data analysis procedures (Campbell & Stanley, 1963; Tashakkori & Teddlie, 1998). This methodological design was utilized to compare the extent of change in groups of grade 6-8 students' conceptual understanding of matter units as well as their constructed argumentation understanding.

Materials and Data Collection Tools

The research literature provides substantial suggestions to develop interactive learning materials for facilitating meaningful science learning through argumentation (e.g. Jonassen & Kim, 2010; Karacapilidis & Papadras 2001; Nussbaum, 2008; Osborne et al., 2004; Osborne et al., 2013; Reznitskya, Anderon, McNurlin, Nguyen, Archodidou, & Kim, 2001; Slotta & Linn, 2000; Weinberger et al., 2010; Yeh & She, 2010). Those suggestions were implemented in a multimedia-rich online setting called Argumentaryum whose framework is given in Figure 1 (for details, see Amuce, Ardac, & Akpınar, 2010; Akpınar, Ardac & Amuce, 2011, Akpınar, Ardac & Amuce, 2013). The main features and components of the system are as follows (see Figure 2 and 3 for screen-shots of the system): Interactive actitivities of the virtual rooms of the system represent and contain the curricular content of four learning units in science domain for 6-8th graders. The learning activities or the task regime of each unit was developed for the units named as particulate nature of matter, structure of matter, features of matter, and heat and matter.

The system consists of seven different virtual activity rooms, namely observation/simulation room, video room, meeting room, decision room, game room, race room, and expert room. The set of these virtual rooms provide multiple representation tools to simulate and sustain a dialectic argumentation process, and sufficiently exercise argumentation activities. Each room was designed to serve a series of learning objectives for conceptual development or procedural skills. At the start, the system presents a contextualized problem, and the student is required to provide or select an answer as her claim. As the student progresses through activities of the virtual rooms, she finds and collects evidence for her claim, and develops/selects arguments for the problem/answer at hand. The activities in the system aim to help students both learn the content of the curricular units, and develop skills necessary for scientific argumentation such as predicting, observing, explaining, hypothesizing, testing claims, and providing evidences. Hence the system presents observation and manipulation tools to students.

Students operate and inspect the given simulations regarding the problem case, conduct experiments for the problems, inspect video segments, study textual explanations provided along with visual representations including molecular representations, record their answers and activities as well as notes, e-communicate with other students via built-in e-messaging system, participate in e-discussions, evaluate alternative viewpoints, play e-games and race regarding the problem domain, and finally form/modify arguments. These activities aim to present task regimes to get students to elaborate, debate, and reflect on their own and others' ideas in a mode of possible egalitarian participation on argumentative discourse.

The discussion room and e-messaging platform provide students with writing frames, including sentence-openers, in order to ease argument writing. These were built as scaffolding tools to facilitate development of argumentative dialogue. Also, when each problem is asked (authentic tasks), three incorrect claims and one correct claim are presented to students so that if they cannot form their own claim/answer, they can select one from those provided, and whichever method of answer they select, they have to search and provide evidence for their claims/answers in virtual rooms within the system.

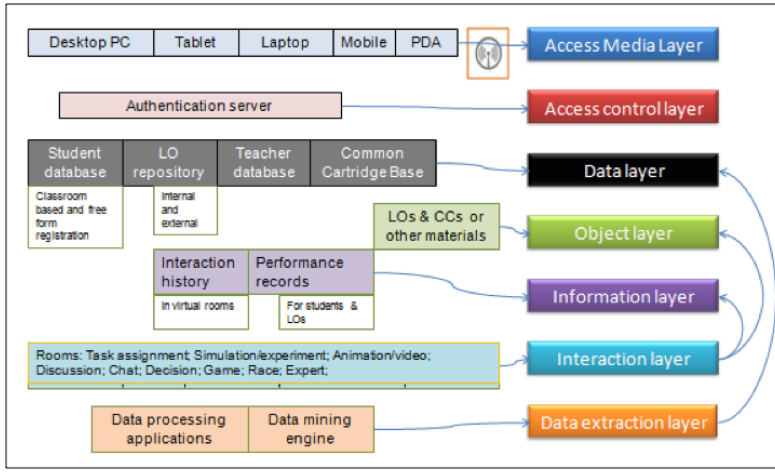

Figure 1. Argumentaryum framework and its components (Akpınar et al., 2011).

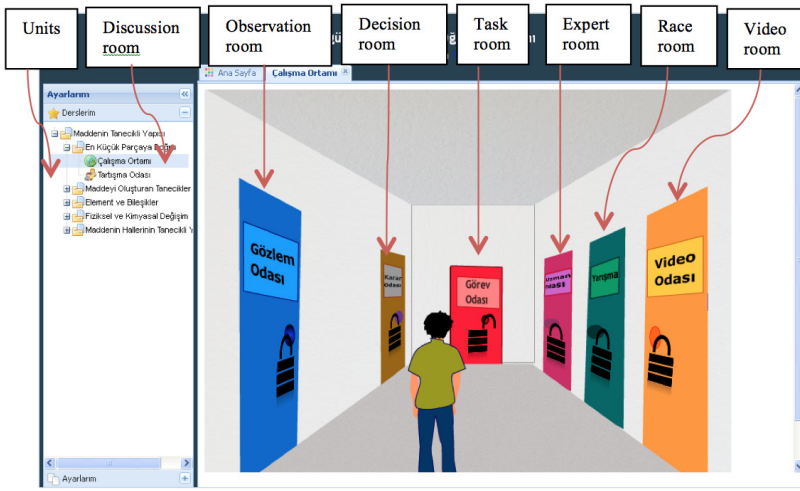

Figure 2. A screen shot of the Argumentaryum entry window.

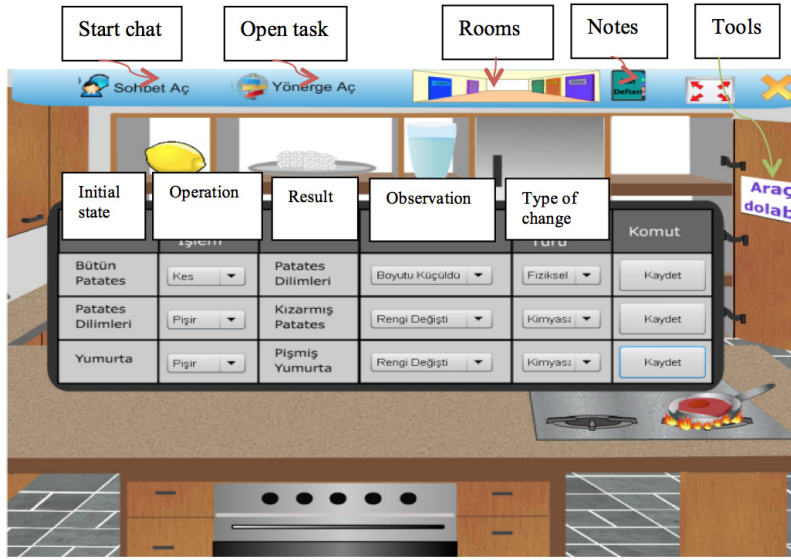

Figure 3. A screen shot of the Argumentaryum observation room.

Different tools were used to collect data in this study. These tools were:

(i) LOG files of the system which keep user actions on each component of the system.

(ii) Achievement tests consisting of a paper-based test including both multiple choice and short essay items to measure the students' knowledge of a learning unit covered within the Argümantaryum. For each unit, different tests were developed by teachers and researchers bearing in mind the learning objectives. The tests were developed as pre and post tests, and covered similar items. Only the face and content validity of these tests were checked by the research team, considering learning objectives, and no specific reliability studies were conducted.

(iii) Test for scientific discussion skills using a paper-based test, adapted from Marttunena et al. (2005) and Victor (2007), aimed to measure argumentation and scientific discussion skills. The tasks were originally written in English, and then translated into Turkish, confirmed by several language experts. The reliability of this method was found to be good (Marttunena et al., 2005). Overall, these tasks measured four dimensions: a) analyzing an argumentative text, b) composing claims and arguments, c) commenting on an argumentative text, and d) judging arguments and conclusions. Students are asked to select and explain claims and evidence regarding the given problem cases. The tests were conducted twice, before and after the students use the system.

(iv) A usability questionnaire consisting of fifteen Likert-type items asking students to reflect on their experience using the system. In addition to these data collection tools, classroom observation of the teachers and the researcher, and interviews with teachers and students provided data.

Study Sample

The system was examined with two different studies to test the hypotheses, and to search for possible ways and problems of its effective use. The sample, which was selected from a pool of schools in a metropolitan city, based on accessibility, consisted of 207 students (6th and 8th grades) of three schools, one of which was private and two public state schools. The first and the second hypothesis were tested in the first study with 136 6th graders in five classrooms of two teachers, one each for individually and collaboratively studied students. The third and the fourth hypothesis were tested in the second study with 71 8th graders in three classrooms of the same teacher. To avoid biases, headmasters of the schools allocated classrooms to the study groups. The selected schools accept students without conducting any entrance exam, and do not classify students according to their ability. The age range of the sample varied from 12 to 15. The students' prior science achievements in these schools are similar, partially confirmed by the pretest scores. The schools attract students mainly from low and middle-class families. The study, however, has a limitation: The sample was not a random selection of students, but rather it was, in effect, a convenience sample. Therefore, the reader must be cautioned against generalizing these results.

Data Collection Procedures

First, to test the hypotheses that collaborative use of the Argumentaryum under a teacher guidance will help learners to develop more conceptual knowledge and better scientific discussion skills than students who use the platform individually without teacher guidance, the students of the five 6th grade classrooms were assigned to two groups; two classrooms (n=40) for using the platform individually without a teacher guidance (CS), and three classrooms (n=96) for using the platform collaboratively under a teacher guidance (CHS). Before the students utilized the platform, two tests, one for measuring their existing knowledge of the learning unit, and the other for measuring their scientific argumentation skills, were administered as the pretests, whose parallel versions were later used as the posttests. Following the pretest administration, the computer supported group studied the learning unit, particulate nature of matter, in two lesson hours in the

Argumentaryum about which a detailed hands-on presentation was made to the students by one of the researchers. While working on the platform, the computer supported group did not receive any guidance from their class teachers though the teachers observed the classrooms. When all the students completed the task regime (set) of the platform, they were asked to repeat the study at home, and focus on discussing the claims and share arguments within the virtual meeting room. However, following the presentation about the platform, the computer and human supported students were asked to select a partner to study together on a computer station for three hours. These students studied the same task regime of the platform, and received their teachers' prompts and remarks on certain problems and simulations, as well as considering alternative arguments including partners' views. Also their teachers asked them to use the virtual discussion room to share and discuss a claim with the entire class. Though most students preferred to speak out their claims and comments, the teachers asked them to note down their statement on the discussion board so that others in the class could read it and write comments using the argumentation writing frames, sentence openers. As suggested by Noroozi, Weinberger, Biemans, Mulder, and Chizari (2012), students in this group were asked to manipulate the computer on a rotating basis to prevent learners from getting stuck in their functional roles rather than focusing on task performance.

Second, to test the hypotheses that collaborative use of the Argumentaryum under a teacher guidance will help learners to develop more conceptual knowledge and better scientific discussion skills than students who study the same learning unit with a teacher within a conventional classroom setting, the students from the three 8th grade classrooms were assigned into two groups, (n=46) for the collaborative use of the platform with a teacher guidance (CHS), and one classroom (n=25) for the conventional activities developed and directed by the classroom teacher (HS). This latter group studied the learning unit in eight hours over a period of two weeks while the former group studied it in three hours.

DATA ANALYSIS

The data collected through unit achievement tests and tests of scientific discussion skills were first checked for normal distribution, and then statistically analyzed. Since some of the test data set was not normally distributed, non-parametric tests (Kruskall Wallis, Mann-Whitney U and Wilcoxon Signed Rank test) were used; however, all tests were verified with a parametric equivalent. Mann-Whitney U tests revealed that the first ($U=1884.00$; $Z= -0.174$; $p=.862$) and the second ($U=2177.50$; $Z= 1.237$; $p=.216$) hypothesis were not verified. Both scores of achievement and

scientific discussion skills of computer and human supported students who collaboratively use the argumentation-based multimedia science learning environment for the unit particulate nature of matter under teacher guidance did not significantly differ from the same type of scores of students who use the same platform individually without teacher guidance. In addition, Wilcoxon signed rank tests showed whether each groups' progress from the pre to post tests was significant, revealing the finding that the computer and human supported groups' progress in both conceptual knowledge (Z=-2.076, p=0.038) and in scientific discussion skills (Z=-3.050, p=0.002) were significant. However, the computer supported group did not make significant progress either in conceptual knowledge (Z=-1.950, p=0.051) or in scientific discussion skills (Z=-0.077, p=0.938).

Table 1

Effect Size Measures for the 6th Graders

Study mode		Conceptual knowledge				Post-Pre dif		Effect size: Hedges' g	
		Pre-test		Post-test					
	n	mean	sd	mean	sd	mean	sd		
Computer Support	40	4.13	1.52	4.83	1.75	0.70	2.23	0.43	Medium
Computer & Human Support	96	4.69	1.72	5.23	2.15	0.54	2.62	0.28	Small
		Scientific discussion skills				Post-Pre dif		Effect size: Hedges' g	
		Pre-test		Post-test					
	n	mean	sd	mean	sd	mean	sd		
Computer Support	40	5.23	3.14	5.18	2.61	-0.05	3.54	-0.02	Negligable
Computer & Human Support	96	5.47	2.60	6.52	2.78	1.05	3.18	0.39	Medium

We also conducted a series of effect size measures for each variable in the groups of both 6th and 8th grades, shown in Table 1 and 2 respectively. Accordingly, though Hedge's g effect size value for computer supported and individually studied 6th graders (g = 0.43) suggested a medium practical significance in conceptual knowledge development, it suggested a small effect (g= 0.28) for computer and human supported students. Further, while

Hedge's g effect size value for computer supported 6th graders suggested a (g = -0.02) negligable practical significance in developing scientific discussion skills, it suggested a (g= 0.39) medium effect for computer and human supported students. It has to be noted that the number of students in each experiemental group is not similar; it is 40 in one group and 96 in another. This inequivalency in the group sizes may have influenced the results. In short, for the 6th graders, while use of the system helped the computer supported students develop more conceptual knowledge, they helped the computer and human supported students develop more scientific discussion skills. Though statistically insignificiant, it may be stated that collaborative use of the system with teacher support, as expected, fed the development of discussion skills by getting students to share ideas and claims, and to argue over claims, evidence, and counter evidence.

Table 2

Effect Size Measures for the 8th Graders

Study mode		Conceptual knowledge				Post-Pre dif		Effect size: Hedges' g	
		Pre-test		Post-test					
	n	mean	sd	mean	sd	mean	sd		
Computer Support	25	2.59	1.36	4.13	1.92	1.54	2.59	0.93	Large
Computer & Human Support	46	2.36	1.32	4.64	2.46	2.28	2.57	1.15	Large
		Scientific discussion skills				Post-Pre dif		Effect size: Hedges' g	
		Pre-test		Post-test					
	n	mean	sd	mean	sd	mean	sd		
Computer Support	25	5.70	2.91	5.83	2.69	0.13	3.19	0.05	Negligable
Computer & Human Support	46	7.24	3.40	8.40	3.27	1.16	3.73	0.35	Medium

To test the third and fourth hypothesis, Mann-Whitney U tests were conducted. The tests showed that the third (U=633.00; Z= 0.70; p=.48) and fourth (U=679.00; Z= 1.254; p=.208) hypothesis were not verified. Both scores of achievement and scientific discussion skills of computer and human supported students who collaboratively use the argumentation-based multimedia science learning environment for the unit features of matter did

not significantly differ from the same type of scores of students who study the same learning unit with a teacher within a classroom based setting. Moreover, Wilcoxon signed rank tests showed whether each groups' progress from the pre to post tests was significant: Both groups' progress in conceptual knowledge (CHS: Z=-3.549, p=0.001; and HS: Z=-3.476, p=0.001) were significant, though neither of the groups' progress in scientific discussion skills (CHS: Z=-0.534, p=0.59, and HS: Z=-1.554, p=0.120) were significant. Further, Hedge's g effect size values for both groups of 8th graders (g = 0.93 for HS group, and g= 1.15 for CHS group) suggested a large practical significance in conceptual knowledge development. It is higher for the group that used the Argumentaryum collaboratively under teacher guidance. However, while Hedge's g effect size value for human supported group suggested a negligable (g = 0.05) practical significance in developing scientific discussion skills, it suggested a medium (g=0.35) effect for computer and human supported students. In brief, for the 8th graders, it should be cautiously stated that the online activities with human teacher's support helped the collaboratively studying students to develop relatively more conceptual knowledge and more scientific discussion skills, though the difference was not statistically remarkable.

When the Argumentaryum server log files were analysed for computer support and computer and human support groups, it was found that the average number of attempts to complete a video activity is 1.81, the average number of attempts to complete a decision activity is 1.33, the average number of attempt to carry out each race/drill activities is 1.00, and the average number of attempts to complete a simulation/observation activity is 2.06. Considering the average period of time spent in the virtual activity rooms, it was observed that the average time spent in race room is 2.07 minutes, in decision room is 7.56 minutes, in simulation/observation room is 13.01 minutes, in help and expert room is 3 minutes, and in video room is 5.05 minutes. These figures show that attempts and allocated time are relatively small.

Table 3

Arguments Written by a Classroom of 6th Graders

Grade 6	A guiding question in the board:	
	"Is *all matter particulate* in nature or not? Write your answer by starting either "*All matter* is *particulate* in nature because…." or "*All matter* is NOT *particulate* in nature because…."	
Student ID	**Student entry**	**Reply to**
80	*Yes, after my observation in the observation room, I concluded that all matter* is particulate in nature. (first student replying the question in the board)	Question
75	*Each matter* is *particulate* in nature because a matter is collection of small parts.	Question
83	*Each matter* is *particulate* in structure because I saw the particles when I looked into the matter through the magnifier.	Question
81	*All matter* is *particulate* in nature because *when we divide a matter many times, we got smaller bits. But when we looked into a matter through a microscope* in the software, I saw that matter has particulate structure. I recommend all of you do the same observation	Question
86	*All matter* is *particulate* in nature because *we divide a matter into pieces, but we cannot see particles in small pieces, we can only see them with a microscope.*	Question
63	*All matter* is *particulate* in nature because all matter consists of atoms.	Question
74	*I agree because I saw that evidence in our experiments.*	Question
82	*Yes.*	Question
66	*Particles are the smallest constituting component of a matter.*	Question
67	*All matter* is *particulate* in nature because *we saw that through a microscope, the smallest parts we saw through a microscope come together in pressed way to make a matter.*	Question
73	*All matter* is *particulate* in nature because *all matter occupies a space, and there are spaces between particles.*	Question
85	*All matter* is *particulate* in nature because *all matter consists of small parts, difficult to divide further and too small to see.*	Question
78	*All matter* is *particulate* in nature because *the smallest component can be seen through a magnifier.*	Question
68	*All matter* is *particulate* in nature *because I saw the smallest components through a magnifier in activities.*	Question
85	*Yes, it is.*	ID 81
79	*All matter* is *particulate* in nature because *I saw the smallest components of a matter through a magnifier in the activity.*	Question
69	*Yes, because a matter consists of atoms, we could see them in experiments we conducted in argumentum observation room.*	Question
64	*Each matter* is *particulate* in structure because each matter consists of particles that we cannot see.	Question
67	*Each matter* is *particulate* in structure because we see those smallest particles through a microscope.	ID 81
70	*All matter* is *particulate* in nature because *matters have got atoms, and atoms have small particles.*	Question
53	Yes, it is so.	Question

The students' use of the discussion room was examined by checking the log files of the board. The log files recorded the system-student and student-student interaction on the board, kept records of: the time students enter into the board, time spent on the board by each student, provided guiding questions, students' writings on the board, students' responses to each other, and the connection between the guiding questions and the other relevant tasks as well as the sentence openers used by each student. To encourage students' argument production, a guiding question for each activity was displayed on the discussion board just after the students completed their experiments and observations on the system. To get all students to contribute to the discussions, they were not allowed to further proceed in the system without writing at least one entry into the board. Table 3 displays arguments written on the board by one of the 6th grade classrooms who individualy (computer support only) studied the system. All of these students' entries were originally in Turkish, and the translated form is provided here. It is observed that all students, except two, replied to the question, and did not provide any comments, counter arguments, or a new argument, but confirmed the correct alternative given. Two students (ID 67 and ID 85) wrote arguments as responses to the guiding question and wrote responses to one of their friends' (ID 81) argument. Those two students' response arguments were not counter arguments, because they both confirmed their friend's argument. However, there were two students who entered into the board more than once: Student ID 79 entered into the board eight times without changing her first argument, and ID 67 entered 15 times keeping her first argument as a reply to the question, but she rephrased her argument as a response to one of her friend's (ID 81) arguments. A few other students neither used the answer/claim structure suggested in the guiding question nor used the sentence openers provided on the board, but they preferred to simply confirm the first alternative (correct) answer to the question by writing shortly "yes (ID 82) yes it is so (ID 53)"; their answer did not contain arguments explaining a reason or an evidence. All other students provided responses with a reason by referring to the experiments and observations they conducted in the Argumentaryum environment. As a result, the students did not thoroughly discuss the argument with different view points, though their selected argument was correct.

DISCUSSION AND CONCLUSIONS

The study hypothesized that collaborative use of the argumentation-based multimedia science learning environment will help students develop more conceptual knowledge of the units and better scientific discussion skills than the use of the same platform in the mode of computer support only,

and classroom instruction only. However, the hypotheses were not confirmed. Once all the statistical tests and effect size measures are considered together, the collaboratively studying groups made remarkable progress in conceptual knowledge both in 6th and 8th graders' experiments. Conversely, whilst their progress in scientific discussion skills in the first experiment was significant, it was not significant in the second experiment with 8th graders; Hedges g effect size showed that the system helped CHS groups to a certain extent develop conceptual knowledge and scientific discussion skills. The system also helped the 6th graders studying individually make significant progress in conceptual knowledge, but did not help them develop significant scientific discussion skills. Also, HS group which functioned as control group to CHS group did also make significant progress in their conceptual knowledge, but the progress of this group in scientific discussion skills was insignificant. As a result, it may be stated that the developed platform has instructional potentials when it is used particularly in the mode of a collaborative learning environment supported by a teacher. This result partially confirmed the results of a similar study by Zumbach (2009) which revealed that the assignment of an argumentation task in media rich learning environments was an effective instructional strategy that led to enhanced knowledge acquisition compared to learning without an argumentation task. In this study, HS only group also developed conceptual knowledge and discussion skills, which may be interpreted as the eight graders can manage their own learning and are very accustomed to human support in learning and skill development.

The students who used the system individually without teacher guidance (CS) did not benefit from the system as much as collaborative groups, who additionally received teacher guidance (CHS). This finding supported the earlier literature (Ravenscroft et al, 2007). Nevertheless, as both of these groups interacted with the system for a relatively limited period of time, the results should be interpreted positively, and encourage the development endeavor. As the literature points out (Anderson et al, 2001; Driver et al, 2000; Johnson & Johnson, 1994; Jonassen & Kim, 2010) to develop sound arguments, students should engage in interactive platforms to reason, share reasonings, and draw conclusions on the basis of discussions in order to resolve their cognitive conflicts. Studying with meaningful activities in interactive environments is a prerequisite to develop arguments (Jonassen & Kim, 2010). The Argumentaryum platform as an interactive environment with thought provoking and supporting tools that helped students to study the material in a meaningful manner. Though the students had limited opportunity to use all of the capabilities of the system, the system can provide learning opportunities for students, particularly, in particulate nature of matter unit. For example, the students did not have enough time to use

the argumentation sentence-opener supported discussion board and e-communication platforms. In fact, when the time was allocated for writing in e-communication platforms, many students found it needless because if the person with whom they would argue is with them, they would prefer talking to them rather than writing. It seems that e-communication would suit more to students who are distant from each other. When the students were asked to continue arguing over the discussion forum at home, server log files indicated that many students do not use those options at home. This result may verify the findings that learners using synchronous modes achieve more integration and construction of arguments and discussions (Veerman, Andriessen, & Kanselear, 2002). Further, as previous studies emphasized, when the purpose of argumentation based science learning is to deepen learners' knowledge or produce productive arguments, argument writing tools and tasks could be useful (Noroozi et al, 2012; Suthers & Hundhausen, 2003). In the Argumentaryum, integrated e-discussion modules with argumentation, sentence openers functioned well. However, as the number of learning support tools regarding knowledge representation tools was high (videos, animations and simulations, molecular representations and textual explanations) in the Argumentaryum, the students focused more on inspecting those representations and spent less time on writing tasks and argumentative texts, that, in turn, may have caused less use of online discussion boards. Hence, special sessions for writing arguments, starting with discussion modules with argumentation sentence-openers and gradually fading tools should be organized.

In using the system, the following problems were encountered, and they have to be resolved before further studies. Students did not provide counter arguments on the discussion forum. To overcome this problem, students could be asked to comment on a certain number of different counter arguments to be presented by a teacher in the forum. Hence moderation by a teacher or by an able student may be considered. In addition, students preferred to engage more in the visual aspects (e.g. simulations) rather than writing their point of views in discussions. Speech recognition software and speech-to-text tools may be integrated to the platform so that students may easily input their ideas into discussions. Reflective coaching strategy appears to be another approach for the middle school students. Also, teachers thought that the system would not be used by the students, which in turn gets teachers to avoid using some of the features, e.g., discussion board. Whilst students are discussing via the system, teachers cannot predict the amount of time to be allocated to the discussions; as a result, they may then stop an argumentation process before it is finalized. It seemed that some teachers were afraid of losing classroom control in collaborative argumentation process as pointed by Kreijns et al (2003). Finally schools that are not

willing to allocate a significant amount of time to conduct an application in their settings would lead the students to have limited interaction with the system.

It seems that the time period for inspecting argumentation systems and completing given tasks is relatively short; however, it is obvious that students should be given more tasks to elaborate the content and reinforce possible learning. When students use the system more, it is thought that the development of conceptual knowledge and scientific discussion skills would increase.

This study adds to a growing body of work on argumentation based science learning (e.g., Noroozi et al., 2012). It shows that using a multimedia enhanced learning setting supports the argumentative processes, but does not optimally provoke debate between students. Moreover, students seemed not to take full advantage of the collaborative setting. Possible causes can be sought in the lack of time with tools and different modes of the use of the tools. Further research is necessary to learn more about individually and collectively (co)constructing knowledge under different amounts of rich media and/or rich media and human support along with other variables involved in science learning. Additionally, as computer and human support and only human support mode seem to influence learning more, and computer and human support mode improved discussion skills better, further studies should investigate types of teacher interventions when using the system. In addition, those studies should consider comparing the effectiveness of the system to alternative e-learning tools, if there are any comparable sets of tools available. Finally, in this study, the effects of various types of computer based representations with argumentative tasks were tested in combination with or without human support, and compared human support only learning and skill performance to computer and human supported one. However, interaction effects of each computer based representations on argumentative knowledge construction have not been thoroughly investigated. Future studies, one of which is currently underway, should focus specifically on the interaction effects of various representations with different degrees of human support and guidance.

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