Development and validation of an argumentation based multimedia science learning environment: Preliminary findings

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Abstract

Technology based settings have variety of assets and possibilities for learning elementary level science. This study has designed and developed a computer based environment, Argümantaryum. It provides virtual experiment facilities, visually rich multi representations of contents, video and simulations at which students may base their arguments and learn some elementary level science units. It has also a built-in discussion forum and an instant messaging component both contain argumentation sentence-openers. Following the implementation, the system was tested in real classroom settings under different study schemes for different learning units. When the system is used in the mode of a peer collaboration supported by a teacher (compared to individual use without a teacher support), it helps students to make progress in terms of both scientific discussion skills and knowledge of the learning units accommodated in the platform. Though, similar results were obtained when the same usage scheme is followed for another learning unit, we could not entirely confirm the previous finding. Further, the system performance in supporting collaborative work with teacher guidance was compared to lecture based learning. Although both collaborative use of the system under teacher guidance and the lecture based activities significantly helped their students to develop knowledge of the learning unit, the lecture based activities helped to develop better scientific discussion skills. The students who used the system individually without teacher guidance could not benefit from the system as much as collaborative groups who also received teacher guidance. Finally, the report provides a discussion and a set of recommendations on how to further test the platform facilities.

Keywords: Argumentation, learning elementary science, online learning tools, multiple representations

1. Learning science through argumentation

Recently the studies suggested to get students to argue over concepts and procedures of science learning unit to develop better understandings because to get involved in argumentation help conceptual change in the minds of students (Driver et al., 2000; Nussbaum, 2008). 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 are elaborated and debated where students can reflect on their own ideas and others’ ideas (Cross et al., 2008; Yeh & She, 2010). Scholtz (2008) classifies 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), (4) to practice subject specific modes of scientific discourse (Lemke, 1997). However, constructing acceptable and sound arguments is not an easy task, and students need guidance and help (Osborne et al., 2004; Yeh & She, 2010). Different tools and mechanisms had been developed for supporting argument construction (e.g. Buckingham et al., 1997; Hirch et al., 2003; Karacapilidis & Papadias, 2001; Simon, 2008). For example argumentative sentence-openers were designed to provide students with scaffolding tools to facilitate development of argumentative dialogue within an interactive dialogue game (Ravenscroft, 2007; Ravenscroft et al., 2007). These tools, according to Osborne et al (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. Further, argument visualization tools such as concept maps, matrices, hierarchy trees, and Vee diagrams have been designed to support argument construction. Though limited, there are some evidence that software argumentation templates provide increased claims about how to solve problems (Cho & Jonassen, 2002, Li & Lim, 2008, Saye & Brush, 2002). Thus students’ inquiry skills may be enhanced through scaffolding them with argumentation templates.

Students’ argumentation has great potential for fostering communication skills to interchange perspective and meanings (Yeh & She, 2010, p. 589). Yeh and She (2010) define the essential cognitive components of constructing scientific arguments as assessing alternative viewpoints, filtering evidence, commenting on qualitative representations and validating scientific claims. However, practical work on conceptual change in science lesson through argumentation is small in number (Weinberger et al., 2010). One of the hurdles to develop students’ scientific argumentation skills is the lack of opportunity to drill argumentation activities in classroom settings, and the lack of tools that may simulate dialectic argumentation process where students play a major role. Therefore 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.

2. Research problems

This study aimed to develop and examine an environment for facilitating science learning through argumentation. The developed system, Argümantaryum, outlined below, was examined with students and teachers to test the following research hypotheses under different learning scenarios: Students who use the argumentation based multimedia science learning environment collaboratively under teacher guidance will be (1) more successful in unit tests and (2) develop better scientific discussion skills than students who use the same platform individually without teacher guidance, and (3) more successful in unit tests and (4) develop better scientific discussion skills than students who study the same learning units with a teacher within a classroom based setting.

3. Method and materials

This mixed method research integrated a quasi-experimental control group design with a pre and post tests, along with qualitative data collection and quantitative and qualitative data analysis procedures. This methodological design was utilized to compare the extent of change in groups of 6-8th graders’ conceptual understanding of structure of matter as well as their constructed argumentation understanding. The research literature provides substantial suggestions to develop interactive learning materials for facilitating meaningful science learning through argumentation (Jonassen & Kim, 2010; Karacapilidis & Papadias 2001; Nussbaum, 2008; Osborne et al., 2004; Reznitskaya et al 2001; Weinberger et al., 2010; Yeh & She, 2010). Those suggestions were implemented in a multimedia-rich online setting, called Argümantaryum whose framework is given in Er et al., (2010) and Akpınar et al., (2011). The main features and components of the system are as follows: Interactive activities of the virtual rooms of the system represent and contain the curricular content of five 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, nature of matter and features, 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. Each room was designed to serve for a series of learning objectives for conceptual development or procedural skills. At 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 the activities of the virtual rooms, she collects evidence for her claim, and develop/select 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 as prediction, observations, explanation, hypothesizing, testing claims and providing evidence. 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, 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. The discussion room and e-messaging platform provides students with writing frames, sentence-openers, for easing argumentation writing. Also, when each problem is asked, possible 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 the givens, whatever method of answer they select, they have to search and provide evidences for their claims/answers in the system.

The system facilities were examined with three different studies (two is reported here) to test the study hypotheses, and to search for possible ways and problems of its effective use. The sample selected from a pool of schools in a metropolitan city based on accessibility consisted of 234 students from ten different classrooms (6-8th grade) of three schools, one private and two state schools. The first and the second hypothesis were tested in the first study with 136 6th graders in 5 classrooms. The third and the fourth hypothesis were tested in the second study with 71 8th graders in 3 classrooms. The use of the system as a teacher tool was tested in the third study with 20 6th and 7th graders from two classrooms. To avoid biases, headmasters of the schools allocated classrooms to the experimental and control groups. The selected schools accept students without conducting any entrance exams, and do not class students according to their ability. The age range of the sample varied 12 to15.

3.1. Data collection procedures and data collection tools

To test that collaborative use of the Argümantaryum under 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 into two groups, two classrooms (n=40) for the individual use of the platform without teacher guidance (IND), and three classrooms (n=96) for the collaborative use of the platform with teacher guidance (COL). Before the students utilized from 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 IND group studied the learning unit, Particulate Nature of Matter, in two lesson hours in the Argümantaryum about which a detailed hands-on presentation was made to the students by one of the researchers. While working on the platform, the IND group did not receive any guidance from their class teachers though the teachers observed the classrooms. When all students completed the task regime of the platform, they were asked to repeat the study at home, but focus on discussing the claims and sharing arguments within the virtual meeting room. However, following the presentation about the platform, the COL group students were asked to select a partner to study together on a computer station for three hours. The COL group studied the same task regime of the platform, and received their teachers’ prompt and remarks on certain problems and simulations, as well as considering alternative arguments including partners’ views. Also the COL groups were asked by their teachers to use virtual meeting room to share and to 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 to the discussion board so that others in the class can read it and write comments, using the argumentation writing frames, sentence openers.
To test that collaborative use of the Argümantaryum under 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 classroom based setting, the students of the three 8th grade classrooms were assigned into two groups, two classrooms (n=46) for the collaborative use of the platform with teacher guidance (COL), and one classroom (n=25) for the conventional activities developed and directed by their classroom teacher. Finally, to test the Argümantaryum as a teacher tool, a seventh grade science teacher used the system to support her instruction of the unit “Particulate Nature of Matter and Features” to seven students.

In order to collect data mainly five different tools were used. These are: (a) LOG files of the system which keeps user actions on each component of the systems, (b) Achievement Pre-tests and post-tests, (c) Test for scientific discussion skills, (d) A usability questionnaire: In addition to these data collection tools, classroom observations of the teachers and researcher, and interview with teachers and students provided data.

4. Data analysis and findings

The data collected through achievement tests and tests of scientific discussion skills were statistically analyzed. First, the data sets were checked for normality. Since some of test data were not normally distributed, non-parametric tests (Kruskall Wallis, Mann-Whitney U and Wilcoxon sign) were used, however, all tests were verified with a parametric equivalent. A Mann-Whitney U test (U=1464.50; Z= -2.198; P=.028) revealed that students who use the argumentation based multimedia science learning environment for the unit Particulate Nature of Matter collaboratively under teacher guidance developed better scientific discussion skills than students who use the same platform individually without teacher guidance. For the same learning unit, Wilcoxon sign test revealed that collaboratively studying students made significant progress from pre to post tests on both unit achievement tests (Z= -3.050; p=.002). However, in neither of the tests the individually studying students made significant progress.

To test the third and the fourth hypotheses, second study, where 8th grade experimental group students (n=46) use the argumentation based multimedia science learning environment collaboratively under a teacher guidance, and the control group (n=25) received only teacher’s lecture, revealed data for the learning unit “Nature of matter and features” of 8th grade science lesson. The Mann-Whitney U test did not verify the fourth hypotheses. The control group students performed much better at the post-test for scientific discussion skills (U =323.50; Z= -3.046; p=.002). Further, Wilcoxon sign tests showed that both groups (exp: Z = -3.549; p =.001) (cont: Z= -3.476; p = .001) significantly improved their knowledge from pre to post tests. Though this result did not verify the third hypotheses, the experimental group students also made remarkable progress.

5. Discussion and conclusions

Collaborative use of the argumentation based multimedia science learning environment for the unit Particulate Nature of Matter under teacher guidance helped students develop more conceptual knowledge of the unit and better scientific discussion skills than use of the same platform individually without teacher guidance. However, when collaborative use of the system under teacher guidance compared to lecture based activities in a similar learning unit at the 8th grade, this result was not entirely confirmed: Although both collaborative use of the system under teacher guidance and the lecture based activities significantly helped their students to develop knowledge of the learning unit, the lecture based activities helped to develop better scientific discussion skills. The students who used the system individually without teacher guidance could not benefit from the system as much as collaborative groups who also received teacher guidance. This finding supported the earlier literature. However, as both of these groups interacted with the system for a relatively limited period of time, the results should be interpreted positively, and are encouraging the development endeavour. As the literature points out (Anderson et al, 2001b; Driver et al, 2000; Johnson & Johnson, 1994; Jonassen & Kim, 2010) to develop sound arguments, students should engage in interactive platforms to reason, to share reasoning and to draw conclusions on the basis of discussions in order to resolve their cognitive conflicts. Jonassen & Kim (2010) stated that studying in interactive environments with
meaningful activities is a prerequisite for developing arguments. The Argumentaryum is an interactive environment with thought provoking and supporting tools helped students to study the material in a meaningful manner. Though the students had limited time opportunity to use all of the facilities 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 facilities. When students use the facilities more, it is thought that the development of learning and of scientific discussion skills would increase. Finally, whilst the preliminary results provides certain amount of validation data, further analysis of the all experimental procedures (the third experiment and other data), underway, and students’ log data will reveal a better picture of the performance of the developed system. New studies with different study schemes are also scheduled.

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References


