Gradual learning of science in a CSCL environment and the quest of epistemologically sophisticated learners

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Abstract
We have implemented an instructional design for teaching mechanics that combines a Computer Supported Collaborative Learning (CSCL) environment with traditional instruction. We detected superior performance compared with traditional teaching alone and found evidence in favor of the position that certain kinds of epistemological beliefs held by students can inhibit the full realization of CSCL environments’ potential. Our research points to the need of addressing instructionally students’ epistemological beliefs in order to increase the efficiency of many modern learning environments.

1. Introduction

During the last years a broad consensus has been achieved in instructional psychology on certain basic principles that can guide the design of learning environments within the general theoretical framework of social constructivism (Vosniadou 2001). Computer Supported Collaborative Learning (CSCL), has attempted the integration of the above principles through well-designed computer support of the students’ learning activities (Koschman 1996).

Traditional instruction has proved inefficient in handling prior knowledge. For example there is much empirical evidence to suggest that many students after a traditional instruction of Newtonian Mechanics hold ideas about force, motion and the state of rest that are not compatible with the Newtonian theory of motion and that are time and instruction resistant (Hestenes, Wells, and Swackhamer, 1992). Prior knowledge is an active robust system that produces explanations and inferences and resists efforts to change its core assumptions.

In this study we combined traditional instruction of mechanics with a CSCL investigation and tested the results. We established the effectiveness of the design in addressing the robustness of prior knowledge. Moreover we report on evidence that students’ epistemological beliefs can affect the profit gained from participating in the learning environment.

2. Method

Twenty-six (N=26) 10th grade students participated in a didactic sequence, which combined two traditional lessons (“traditional” component) with three CSCL lessons using the software SYNERGEIA (the CSCL component). Before our intervention all students had some contact with formal mechanics taught in the traditional way. The two traditional lessons followed the first and the second CSCL lesson respectively.

The CSCL component was part of the computer science course and was presented to the students as a new way to learn through collaboration. The students worked in groups of three and each group had one PC available. The software that was used (SYNERGEIA) is a data base having both synchronous and asynchronous tools. Students can upload and share files and participate in thread-based discussions. The problem presented for inquiry is the well-known (in Physics instruction) “coin toss problem”. The problem refers to a coin that is tossed straight up into the air, moves upward, reaches its highest point and falls back down again. The students are offered different options for the possible direction and magnitude if the total force on the coin (7 possible answers). They are asked which choice is the appropriate when

1. The coin is moving upward after it is released.
2. The coin is moving downward.

Research shows (Thornton 1994, Mol, in preparation) that most students answer based on the (faulty) intuitive assumption (prior knowledge) that the force is proportional to the velocity. More specifically both before and after traditional instruction success rate is below 5% in question 1 and below 20% in question 2.

During the CSCL lessons the students wrote down their opinions on questions 1 and 2 in the SYNERGEIA database, justified them, read and commented on the opinions of other groups and on texts uploaded for consideration by the teacher. They also reported how their opinions were changing in time and why. The teacher suggested to the students to collaborate, to express freely their opinions, to see the answers of the other groups through SYNERGEIA and comment on them. At some points he asked the students to discuss their opinions face-to-face in the classroom. In no case was he assessing the answers given by the students.
although he pointed some times to inconsistencies of argumentation.

In the “traditional” component of this design no mention was made for the CSCL component. Following the normal curriculum students worked on the problem of “free fall” which is relevant to question 2 in the “coin toss problem”.

The study was complemented by a more detailed study of a group of three students. The epistemological beliefs of these students had been checked using Epistemological Belief Questionnaires (Stathopoulou and Vosniadou in press). The particular students believed that learning is not a quick, timeless and effortless process and therefore were conscious of the effort that they need to expend in order to learn. However they believed that knowledge is something that can be transmitted–handed down from the knower (e.g. the teacher, or perhaps a very successful student) to the learner. These students were videotaped during the last SYNERGEIA class and were interviewed on how they resolved instances of insecure and diverging opinions in the lessons with SYNERGEIA.

3. Results

While working in the first SYNERGEIA hour of the intervention, 70% of the students gave the intuitive answer for questions 1 and 2. None of the students gave the scientifically correct answer in either of our questions. By the third SYNERGEIA hour 70% of the groups were right in both answers. The differences with the percentages reported in section 2 are striking.

The further study of the group of three students showed cases of inefficient use of the learning environment. In a revealing one, students had different opinions on how to answer question 2 but could nor manage the process of building common understanding. Moreover when the teacher intervened to ask students how they could resolve their difference of opinion in a principled way, the students could not answer in a reflective way. In the further question of what scientists would do in a similar situation the students answered that scientists had the needed “knowledge” to decide. Their answer is in agreement with their belief that knowledge is given by some authority.

The same students in the interview showed an awareness of having changed opinions during the intervention (in one case in very specific terms). But they could not explain how this happened. They could not remember instances of interaction that were important in the process of changing their opinions or strategies that they followed consciously to arrive to an agreement. These results indicate that students’ beliefs about the source of knowledge may inhibit them from taking responsibility of the learning process and developing the metacognition needed to manage the process.

4. Discussion and Conclusion

We have established that indeed when prior knowledge makes new learning a challenge (as is the case with the “coin toss problem”), combining traditional instruction with a CSCL investigation is a good instructional strategy. It should be noted that students did not get additional direct instruction (from an authority figure), while using SYNERGEIA. Moreover we provided reasons to research further whether a simplistic view on the source of knowledge is hostile to the development of reflection on the process of learning and therefore compromises students’ skills to manage knowledge production in a CSCL environment. If further research corroborates our evidence it will be proved that it is very important for the efficient performance of a CSCL environment to deal seriously with the development of a constructive epistemology for our students.

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5. References


