Using contrasting cases to relate collaborative processes and outcomes in CSCL

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Abstract: This symposium brings together a panel of researchers using contrasting case methodology to analyze computer-supported collaborative learning in a wide range of learning environments. Such analyses can help researchers better understand the differences in the collaborative processes by sharpening researchers' perception and facilitating the discovery of appropriate explanations for these differences.

With the goal of empirically assessing the effects of support for computer-supported collaborative learning (CSCL), the important question that arises is which variables one should look at. A criticism of most studies investigating the effects of instructional interventions for CSCL is that they have concentrated either on analyzing the collaborative process or the outcomes. We believe that in order to fully evaluate the impact that support measures may have, it is necessary to bring together outcome data and data from collaborative process analyses. Assessing both sources of data in combination allows one to gain insights into the relationship between process characteristics and the collaborative and/or individual outcomes of the interaction. Such analyses are critical for developing a theory of good computer-mediated collaboration. We argue that contrasting case analysis is a promising approach to relate collaborative processes to outcome criteria. Such analyses can sharpen researcher perception by making important differences salient (Marton, 2006). Analysis of distinctly dissimilar cases can exploit the variability among cases and thus facilitate discovery of appropriate explanations which can help in developing coding categories (Firestone, 1993; Strauss & Corbin, 1998). Contrasting cases can, for example, help illuminate the differences between more and less effective groups within one experimental condition or enable the researcher to compare particular types of groups (e.g., effective and less effective groups, heterogeneous or homogeneous groups, same gender and mixed gender groups) across conditions.

The contributions in this symposium have implemented different types of contrasting case analyses in their research. The first paper examines the distinction between the discourse processes of scripted and unscripted learners. The second paper compares successful and unsuccessful dyads who had received script support while learning with an intelligent tutoring system. A rating scale was used to examine variables related to their interaction processes during a collaborative post test. The third paper contrasts more and less successful groups of preservice teachers as they use online resources for problem-based learning; resource use is analyzed from both quantitative and qualitative perspectives. The fourth paper compares sets of contrasting (class) cases to examine factors related to learning outcomes in computer-supported knowledge building settings. Each contribution will begin by discussing the rationale/goal that was used to select particular cases for analysis. Further, the methods used for the collaborative process analyses will be described and the measure that was used to create the contrast will be introduced (e.g., learning gains, number of problems solved, amount of scaffolding needed). A substantial part of the contributions will be dedicated to discussing methodological approaches to combining data from the different sources, and to discussing the results of the contrasting cases analyses. Following the presentations, we will invite the panelists and audience to engage in a discussion to reflect on the kinds of conclusions that can be drawn from this genre of research.

Patterns of discourse and cognition of poor, good, and scripted online learners

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The socio-cultural notion of knowledge construction as being social and mediated through language (Vygotsky, 1978) has strongly influenced the field of CSCL (Koschmann, 1996). CSCL research building on Vygotsky's work has stressed the social nature of knowledge, but individual cognitive processes and knowledge gains have been subject to less empirical research (Salomon & Perkins, 1998). Specific CSCL environments allow think-aloud protocols to be collected while learners are communicating in a text-based fashion and thus, patterns of discourse and cognitive processes can be analyzed (Stegmann, Wecker, Weinberger, & Fischer, 2007). Assuming that there are mutual relations between discourse and individual cognitive processes, we investigate (RQ1), how do poor learners differ from good learners ('poor' or 'good' in terms of small or large individual knowledge gains after CSCL) in their patterns of internal and external speech?

With new technologies mediating communication, CSCL settings have also been conceived as an ideal context to facilitate collaborative learning processes, and consequently, individual knowledge gains (see Koschmann, 1996). Scripting CSCL is an instructional approach that aims to scaffold specific processes of CSCL until learners are capable of self-regulating their interaction processes in a productive way (Fischer, Kollar, Mandl, & Haake, 2007). Scripts facilitate specific discourse activities, and modify individual expectations and cognitive processes. Assuming that scripts take effect at the social as well as the cognitive plane, we investigate (RQ2), how do scripted learners differ from unscripted learners in their patterns of internal and external speech?

Methods

Comparing scripted vs. unscripted CSCL, we conducted a study with 48 students of Educational Science at the LMU Munich. The learning task was to apply attribution theory to problem cases. Participants were randomly assigned to groups of three, and to one of two experimental conditions. Whereas the control group received no additional support in analyzing the three problem cases in three separate discussion boards within the CSCL environment, the scripted learners were assigned to act as *case analysts* for one of the three problem cases and as *constructive critics* for the remaining two cases supported by prompts such as "My proposal for an adjustment of the analysis is". Think-aloud and discourse protocols were collected. Focusing on individual aspects of discourse and cognition, we selected individual learners based on their performance in a knowledge test after the CSCL session (poor vs. good learners) in both conditions (scripted vs. unscripted). Analysis of the discourse data was conducted based on a multi-dimensional coding scheme of propositional segments (Weinberger & Fischer, 2006). We focused on *transactivity of the discourse* (Teasley, 1997), i.e. to what extent learners referred to and operated on the reasoning of their learning partners, and on a specific *epistemic quality of the discourse*, i.e. to what extent learners were able to apply theoretical concepts to problem case information. Both, transactivity and epistemic quality of discourse were ranked as low, middle, or high. The post test on knowledge involved solving another problem case individually; it was similarly analyzed based on the extent learners were able to adequately apply concepts of attribution theory to case information (Weinberger & Fischer, 2006).

Results

With respect to RQ1, results show that poor learners performed well during the collaborative phase in terms of applying a number of theoretical concepts adequately to problem case information without much deep elaboration of the learning material and equally well referred to contributions of the learning partners without much deep elaboration of their messages (see Figure 1). Good (unscripted) learners in contrast, engaged in longer periods of deep elaboration before or during production of contributions of high epistemic quality (see Figure 2).

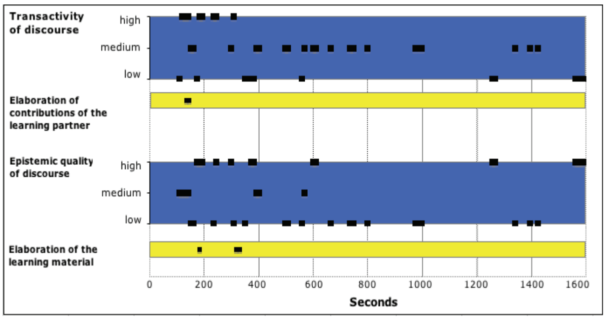

Figure 1. Poor learner

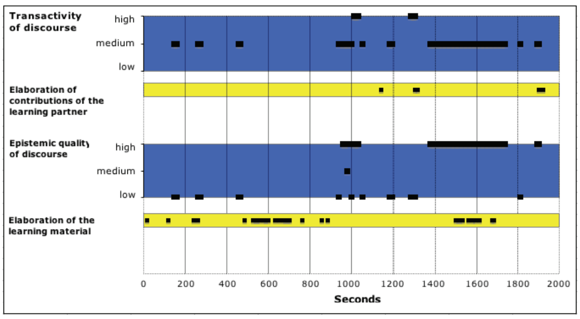

Figure 2. Good learner

With respect to RQ2, analyses show that scripted learners engaged in extended periods of deep elaboration of both the learning material and the contributions of the learning partners leading to an overall higher epistemic and transactive quality of discourse as well as to larger individual knowledge gains. The emerging discourse/ cognition pattern of scripted learners closely resembles the good learner pattern (figure 2). The script applied in this study thus facilitates learners to engage in a good learner mode of thinking deeply (yellow bar) before engaging in discourse activities of high epistemic quality (blue bar).

Conclusions

It is plausible to assume that discourse reflects important aspects of individuals' cognitive processes. Still, the results of contrasting cases of poor, good, and scripted learners point towards some gaps between quality of the discourse and individual cognitive processes and knowledge gains. An approach which could be labelled *surface processing* of the learning material or *satisficing* (Chinn, O'Donnell, & Jinks, 2000) seems to suffice to effectively deal with the learning task at hand, but results in poor individual knowledge gains. Good learners, however, elaborate the learning material to a substantially larger extent than poor learners or simply put: good learners think deeply *before* they write. Both, internal and external speech may not be identical - particularly with good learners - but rather induce each other. With respect to RQ2, we could find that scripts seem to be a feasible approach to model and induce approaches of good learners. These results indicate that scripts could be conceived as process-oriented tools to scaffold and enable learners to engage in deep elaboration of the learning material and in transactive discourse activities rather than to restrict learners' otherwise apparently suboptimal approaches. By contrasting cases, we have found specific patterns of good learning, which can be induced by scripts.

Using contrasting cases to better understand the relationship between students' interactions and their learning outcome

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Ample research has shown that interaction support such as collaboration scripts can improve both students' interactions and their outcome (e.g. Rummel & Spada, 2005). Still, some groups fail despite the guidance they receive. We analyze contrasting cases to answer the question what makes the difference between groups that fail and groups that succeed.

The cases presented were selected from a study on collaborative problem-solving with the Cognitive Tutor Algebra (CTA), an intelligent tutoring system for mathematics education in high schools. In the study (Diziol, Rummel, Spada, McLaren, 2007), we enhanced the CTA to a collaborative learning setting. Although the CTA has shown to improve learning in mathematics (e.g. Koedinger, Anderson, Hadley, & Mark, 1997), it also has been criticized for promoting shallow learning: Students often engage in trial and error strategies and misuse the opportunity to ask for hints by merely copying the correct answers (Baker, Corbett, Koedinger, & Roll, 2004). By promoting mutual elaboration, collaboration can help to overcome these shortcomings (Teasley, 1995). To ensure an effective use of the collaborative CTA environment, we developed a *collaboration script* that guides students' interaction, and encourages them to use their impasses as starting points for elaboration. In the study, we compared individual learning, unscripted collaborative learning, and scripted collaborative learning, all with the CTA. Following an instruction phase, learning was assessed regarding three different aspects: We found a positive script impact on *transfer* and *future collaborative learning*; however, the script did not enhance outcome in the *collaborative retention* test. In fact, scripted dyads even showed a slight disadvantage regarding the outcome variable that assessed the amount of assistance needed to solve the problems. But the variance in this outcome variable was high, indicating that some dyads benefited from scripting while others did not. To better understand the difference between more and less successful dyads on the collaborative retention test, we related students' learning outcome to their collaborative interaction, using contrasting case analyses.

Method

In the retention test, students collaborated on the CTA to solve problems that were isomorphic to those during instruction with script support no longer available. In addition to the CTA logs, all interactions were recorded with audio and screen capture. Outcome variables gained from the CTA logs were the percentage of errors on the first attempt (error rate) and the average amount of assistance needed to solve the tasks (assistance score). Recall that dyads in the scripted condition showed a great deal of variance especially regarding the assistance score. Therefore, we contrasted successful and less successful dyads to unravel reasons for the high amount of assistance needed in some dyads. Since prior knowledge, assessed by students' math grade (in percent), positively correlated with all outcome variables, dyads with an equivalent level of prior knowledge were chosen for the contrasting case analysis to avoid confounds.

To analyze the interaction, we applied a rating scheme that assessed the quality of students' collaboration on two different levels. The first level of analysis focused on the quality of *collaborative problem-solving* during particularly difficult problem sequences: *Mathematical understanding* (MU) assesses the dyad's comprehension of the problem steps, taking both the correctness of their solution and the expressed level of understanding when reading hints or correcting errors into account; *capitalization of the social resource* (SOR) and *capitalization of the system resources* (SYR) assess if students effectively use the learning opportunities given in the enhanced Tutor environment, and *dyad's strategy* (DS) summarizes students' general behavior during problem-solving by describing their main learning strategy with five distinct categories (e.g. trial and error strategy vs. consulting with their partner). On the second level, we divided the problem into several sequences and evaluated students' *collaborative behavior* based on an adapted version of the analysis method developed by Meier, Spada, and Rummel (2007): *Communication flow* (CF) assesses if students show mutual awareness and maintain a joint focus, *mathematical elaboration* (ME) and *elaboration on hint* (EH) evaluate the extent and quality of students' elaboration on their actions and on CTA hints they receive, and *dyad's motivation* (DM) measures students' attitude towards the joint problem-solving activity. We applied the rating scheme to our process data using Activity Lens (formerly known as ColAT), a software tool that permits the integration of several data sources (Avouris, Fiotakis, Kahrimanis, Margaritis, & Komis, 2007). With ActivityLens, CTA log data and video recordings were combined, enabling us to select specific sequences of the video for process analyses. Rating was done on a five-point scale (0 = very bad, 4 = very good). To guide the rater's assessment, a rating handbook described the dimensions in more detail and gave examples for high and low ratings. Analysis of interrater reliability (ICC, adjusted, single measure; Cohen's κ for dyad's strategy) showed good results. Ratings were averaged across sequences, yielding one score per dimension for each dyad.

Results

Table 1 shows process and outcome data of the two focus dyads. Although both dyads entered the learning situation with a similar prior knowledge, the dyad Hertz (anonymous student login) needed substantially more assistance to solve the collaborative retention test than Aristotle. Data from the process analysis could help to explain the difference: although both dyads made a similar amount of errors on the first attempt (ER), Aristotle took greater advantage of both social and system resources (SOR and SYR) offered in the collaborative CTA environment. In particular, they did not engage in trial and error strategy to solve the task (DS), but used the hints offered by the CTA as starting point for elaboration (EH). Also, the amount of elaboration on the mathematical problem (ME) was higher than in the Hertz dyad. This positive collaborative behavior reduced the overall amount of assistance needed from the system (AS). Further, it is interesting to note the high ratings of the Aristotle dyad's communication flow (CF) and their motivation (DM). We cannot judge whether this greater motivation was a consequence or prerequisite for the successful collaboration. To summarize, the better collaborative outcome of Aristotle could be explained by the superior interaction: this dyad was able to transfer the scripted collaborative behavior from instruction to post test. They engaged in mutual elaboration and used the collaborative learning environment more effectively. Further analyses will be needed to see if the dyad's positive interaction can also be found in the collaborative future learning test, that is, if it helps them to approach the new mathematical content. Also, we have to explain the worse interaction in the first dyad, i.e. why they did profit less from the script support. To answer this question, we are currently analyzing their collaboration during instruction and these results will be presented at the conference.

Table 1: Process and outcome variables of two selected dyads

		outcome variables		**process variables level 1**				**process variables level 2**			
Dyad	**PR**	**ER**	**AS**	**MU**	**SOR**	**SYR**	**DS**	**CF**	**ME**	**EH**	**DM**
Hertz	81,0	0,40	2,00	1,0	1,5	1,0	yes	2,3	1,0	1,0	2,0
Aristotle	82,5	0,38	1,03	2,5	3,5	3,0	no	4,0	2,8	2,3	4,0

PR = averaged prior knowledge, ER = error rate, AS = assistance score, MU = mathematical understanding, SOR = capitalization on social resource, SYR = capitalization on system resources, DS = occurrence of trial and error or hint abuse as dyad's strategy, CF = communication flow, ME = mathematical elaboration, EH = elaboration on hint; DM = dyad's motivation. Grey indicates *interaction ratings* higher than 2

Using Contrasting Cases to Understand How Learners Use Online Resources

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The goal of this study was to explore how students use online learning resources and how this may be related to their learning in an online problem-based learning (PBL) environment. Little research has examined students' exploration of learning resources. We believe analyzing contrasting cases is particularly useful when little prior research can inform us what the critical aspects of students' activities are and can help in identifying important resource exploration activities related to students' learning. *Learning resources* refer to the raw materials of learning. Unlike textbooks or handouts specifically tailored to students' grade level and learning objectives, this is not necessarily the case with learning resources. For learning resources to become useful for students' learning, the information in the learning resources needs to be selected and processed further to meaningfully address students' learning needs in the course of PBL.

Methods

This study was conducted in the context of the online STELLAR environment for PBL (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006). The STELLAR system provides preservice teachers with opportunities to engage with learning sciences concepts by using video cases as contexts for collaborative lesson redesign. The system consists of three components: an online learning sciences hypertext, the Knowledge Web (KW); a PBL online module; and a library of video cases that present examples of classroom practice. These cases provide rich contexts for discussion as students engage in redesign of instruction depicted in the cases as well as providing links to the KW, helping students identify fruitful concepts for further exploration. The PBL online module provides tools that scaffold students' individual and group activities, including a personal notebook for recording initial observations, a threaded discussion for sharing research, and a whiteboard where students discuss proposals for lesson redesign. This STELLAR course consisted of 3 online problems, each lasting 2-3 weeks and using a hybrid online and face-to-face course structure. The students' goal was to redesign a lesson based on learning sciences principles. They started by individually studying a video case and recording observations and ideas in an online notebook. The group then identified concepts to explore for their redesign, conducted and shared research, and collaboratively designed lessons. They used threaded discussions and a group whiteboard as shared workspaces in for their online work. The students met face-to-face as they identified concepts to explore and shared the redesign at a poster session. This study examined how students went about selecting and processing information from various learning sciences concepts in the KW.

To identify resource use linked to students' learning outcomes, we selected one high-achieving group (Group H) and one low-achieving group (Group L) and examined how they differ in various aspects of resource exploration. Groups were selected based on mean course grade, which included grades for PBL activities, a take-home final, and a video analysis task. The most effective group had the highest mean grade in the class. The contrasting group had the second lowest mean grade. We did not select the lowest group because of extremely uneven participation. The second lowest group was chosen for contrast because there was relatively even participation among the group. We studied these groups as they worked on the second online problem.

The analysis was based on students' log data and their postings on the Discussion Board and group White Board. Based on these data, we contrasted the two groups on activities related to resource use (e.g., type of resources used, number of visits to resources). The analyses are ongoing, but so far quantitative analyses showed that more successful groups tended to explore resources more widely and deeply (Jeong & Hmelo-Silver, 2008). In this paper, we report on how the two groups differed qualitatively in processing the information provided in the KW.

Results and Discussion

Both Group H and L researched similar numbers of concepts in the KW and posted portions of their research on the Discussion Board. To clearly differentiate how the two groups might have encoded the resources differently, we analyzed the postings on the concepts that both groups researched. There were two such concepts, 'hands-on learning' and 'discussion methods'. Comparison of the contents of posting revealed that the two groups adopted different strategies in processing and posting the results of their research. Group L more or less directly copied and pasted the contents of the KW onto the Discussion Board. On the other hand, Group H, although they also did lots of 'copying and pasting', processed it further. They edited the contents of the KW prior to posting. Their copying was more 'selective' in the sense that they did not copy the whole paragraph, but only parts of it, probably the one's they deemed relevant and important to their current problem. Group H also paraphrased the contents and generated inferences, which can be clearly seen in the following example. Both groups posted what they found out about 'IRE' from the KW. The KW's description is:

> "Initiate, respond, evaluate" is used frequently in what may be labeled the traditional classroom. It has been called the "default pattern" in classroom discourse. The teacher asks a question and the student answers, but its goal seems to be a playback of course content rather than a window into deep learning. Teachers may feel more comfortable with this technique when they seek more control or want to probe comprehension while keeping students more attentive to what they are saying. (See Chinn & Waggoner, 1992).

Group L's posting on IRE was an exact copy of this paragraph down to the citation. In contrast, Group H's posting on the same topic was:

> IRE (Initiate, respond, evaluate) - this is considered the traditional way of teaching. First the teacher asks a question then the student responds and the teacher then either rewards the student if it's a correct answer by appraisal or corrects them with the correct information.

Note that Group H first connected what IRE stands for by putting ‘initiate, respond, and initiate’ inside the parenthesis. This post also summarized the rest of the explanation in the student’s own words. Note also that the last part of the description ‘the teacher then either rewards the students if it’s a correct answer by appraisal or corrects them with the correct information’ was not in the KW’s definition. Thus, the student elaborated the definition.

Regardless of how much information is available as a resource, it needs to be processed and integrated with the learner’s representation and toward the goal of generating problem solutions. Our analysis suggests that what sets more and less successful groups apart was not necessarily the number of concepts researched but rather how they processed and used the information provided in the learning resources. Although contrasting cases were useful in identifying potentially important learning processes, however, these findings remain as hypotheses that need to be further examined but they suggest more formal coding methodologies that might be used in subsequent studies.

CSCL Learning Outcomes Beyond Process: Nature or Nurture?

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Irrespective of the theoretical or methodological subscription of the teacher/researcher, work in the area of CSCL is generally underpinned by the assumption that learning is facilitated by social interactions among learners and that the learning outcomes can be improved through better task design (e.g. whether the production of a concrete deliverable is involved, etc.) and/or process (e.g. use of scaffolds, grouping, awareness tools, etc.) designs. However, do individual characteristics matter? If yes, what characteristics, and how? This paper examines three sets of contrasting cases of CSCL using Knowledge Forum® for asynchronous discussion to identify what kinds of differences appear to contribute to different learning outcomes in knowledge building. The findings point to three important factors associated with different levels of learning outcomes: the extent to which the learners relates to the inquiry problem, the culture and experience of the learners, and the epistemological beliefs of the learner. While the first factor is related to the learning and facilitation design, the second relates to nurture and the third appears to be closer to the innate intellectual orientation of the learner. Some initial thoughts on the implications of these findings are discussed.

Contrasting cases set 1

Two classes of grade 8 students conducted an inquiry on the topic of slimming, the first one (class A) with less facilitation from the teacher, the second one (class B) with closer facilitation and greater expectations from the teacher. The inquiry was carried out over a period of about 8 weeks with weekly class meetings. Students used Knowledge Forum® to conduct their inquiry in groups of two to three students, ending with an informal class presentation of the results. A misconceptions test consisting of items on food, lifestyle and weight management related to slimming was given to the two groups of students at the end of the learning process. Class B accumulated much more discourse data compared to class A, which initially gave the impression that class B was more deeply engaged in the learning task. On the other hand, the misconceptions test results indicated that class A in fact had significantly fewer misconceptions in the food and lifestyle items compared to class B. Further content analysis showed that class A had a higher density of keywords indicating reflection, making claims and questioning than the other class. Class A students appeared to be able to develop greater intrinsic interest and ownership in studying the topic as the teacher was more hands-off while the teacher gave closer monitoring and more in-class discussion of the online discussions.

Contrasting cases set 2

This set of cases involved an international collaboration between two classes of fifth grade students through an online discussion platform with one group more experienced in online knowledge building activities than the other. Before the collaboration, the novice class tended to produce isolated notes filled with information and confined their efforts to their own selected topics. When the more experienced class joined in, the discourse of the students in the novice class changed from information-centered toward more meaningful negotiations; many more of their notes were now linked with one another and they no longer confined their reading and responses to their own study topic. The class more experienced in knowledge building more readily expressed disagreement in their discourse. There was also evidence that the novice class learned to ask more questions in their online discussion from the experienced class. When the joint-collaboration ended, the novice class maintained the changes in interaction patterns that reflected a stronger knowledge building orientation. Besides differences in experience with online knowledge building activities, the difference in discourse behavior could have some relationship with the socio-cultural differences between the two classes. The novice class was situated in Hong Kong and the children were more used to studying given topics and content while the experienced class was from a Canadian school where learning in the school was generally organized around questioning and inquiry. This study was reported at some length in Lai & Law (2007).

Contrasting cases set 3

A class of grade 10 students was conducting online knowledge building activities on a number of topics, first on issues related to energy and later on global warming. While students may be similarly engaged in the discussion in terms of the frequency of their contributions and ownership of the topic under discussion, there can be distinct differences in the ontological categories of the ideas discussed. Some of the students focused their discussions on abstract concepts and tried to understand the mechanisms underpinning the problems of energy crisis and global warming. These students were able to point out early in the discussion some of the prominent misconceptions such as: the term energy crisis is a misnomer as it is more appropriate to refer to the problem as (non-renewable) fuel crisis; and ozone is not a green house gas. On the other hand, many of the students were not interested in understanding the mechanisms or abstract scientific concepts but much more interested in learning about what should be done to solve the energy crisis and how to contribute to slowing down global warming at a personal level (e.g. ways to reduce electricity "consumption" and building solar panels, etc.). Students tended to focus on only one of these two different foci though they were fully aware of the discussion on the other. A closer examination of this discussion reveals that the different discourse foci can be linked to different epistemological orientations of the students – what counts as valuable knowledge to the students. For example, some of the students expressed the following views in their online discussion:

> My theory: I also don't understand why summer streamflows will increase, but we all know that there would be many problems if global warming is not solved. Therefore, is it more worthwhile for us to discuss the solution instead of the impact.
>
> The scientists may find a perfect solution of global warming tomorrow. By the way, what we can do is just we have learnt such as using public transports to replace driving ourselves and use less air conditioners, etc. Think of a ultimate solution is not our work. There will be a great help already if we do our responsibilities.

There appear to be two parallel discussions that went on, one with understanding the scientific concepts and theories about energy crisis and global warming and generic approaches to solving these problems while the other conversation was on enumerating/identifying concrete methods of alleviating those problems. However, as the above discourse excerpts reveal, it is not true that these students were not reading or not aware of the other parallel discussion, but they have chosen the discussion they wanted to engage in because of their epistemological positions.

Discussion

Using contrasting cases reveals different factors contributing to differences in learning outcomes in CSCL settings. The findings from the first set of contrasting cases are in some sense "expected" as these reflect that teachers' behavior and engagement matters and that deeper learning will result from greater personal ownership and intellectual engagement in the topic of study. The findings are also potentially "more useful" in that it sheds light on pedagogical design that can be immediately relevant to the teacher. The second set reveals that the prior experience of students have important impacts on the learning process and outcomes. This finding does have pedagogical implications, but the "solution" is not obvious and involves a much longer term design effort. Implications arising from the third set of contrasting cases are probably controversial. There is no indication that the students' different epistemological orientations (or priorities) were linked to different educational experience. Is the difference innate? Can it be nurtured? Can educational programs be designed to change one's epistemological orientation and if so, what role can CSCL play in it, if any?

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