Multiple Scaffolds to Promote Collective Knowledge Construction in Science Classrooms

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Abstract: In a designed-based study, we investigated the viability of knowledge communities in secondary school science classrooms using Knowledge Community and Inquiry model to guide curriculum design. Based on findings from iteration 1, scaffolds were added to the designed curriculum unit in iteration 2 to help students plan and monitor their collaborative inquiry. Findings from iteration 2 showed more science connections in co-constructed knowledge and higher amount of collaboration among students while constructing shared knowledge comparing to iteration 1.

Objective

Using the Knowledge Community and Inquiry (KCI) model, this study examined how a knowledge community approach in science classrooms could become more accessible to teachers and students by integrating collective knowledge construction in the context of relevant collaborative inquiry activities. In two design iterations, we examined how a co-designed science curriculum unit fostered the development of characteristics of knowledge communities, distributed cognitive responsibility and scientifically sound shared knowledgebase (Scardamalia, 2002), in multiple science classrooms. Curriculum topic for this study was Global Climate Change. A team of researchers, teachers, and technologist collaborated to design a ten week unit on this topic along with technological environment where curricular activities were embedded.

KCI curricula involve three interrelated phases: (A) establishing a community identity, (B) developing shared knowledge through collaborative inquiry, and (C) advancing and interconnecting shared knowledge through further collaborative inquiry (Slotta & Peters, 2008). In the first iteration of this study, students in two classes identified climate change issues of interest. Then, in cross-section groups, they conducted inquiry on the impacts of climate change on seven Canadian regions. By the end of this phase, each student picked a specialist role. In a subsequent inquiry activity, specialists from regional groups worked together to understand the implications of climate change on their domain of specialty across Canada. Students used a wiki with page templates to write their collaborative inquiry reports.

Content analysis conducted on revisions of wiki pages created in regional and specialist groups revealed that the co-designed curriculum had failed to encourage the development of distributed cognitive responsibility and the co-construction of scientifically sound knowledge. Our findings showed lack of highly integrated science content in issues pages. Also, knowledge co-construction was dominated by individuals or subgroups rather than distributed among all group members (Najafi & Slotta, 2010). Here we explain design decisions regarding incorporating reflective and regulative scaffolds in collaborative inquiry activities and report their implications in the second iteration of this study.

Study Design

In iteration 2, five Grade-9 classes participated in the study. We used a customized Drupal website to support collaboration and to represent co-constructed knowledge. In the redesigned unit, first, students from 5 classes engaged in an iterative brainstorming where first all class sections used post-it notes to add important climate change issues to chart papers that were taken from one class section to the next. The last class section reviewed existing issues, added new issues, and categorized all issues to represent important issues. Fourteen overarching categories became the topic of the first small-group collaborative inquiry. Second, small cross-section groups selected a climate change issue and collaboratively conducted a scaffolded inquiry that led to inquiry reports shared in Drupal. Finally, from the list of identified remediation plans from Collaborative inquiry 1, single-section small groups used issues pages to propose modifications to remediation plans.

We used conceptual and empirical literature on knowledge community and inquiry based learning (e.g. White & Frederiksen, 2000) to specify the desired characteristics of knowledge communities and design scaffolds to support them (Table 1). Items addressed in reflection notes fell into two broad categories: Content knowledge and metacognitive and regulative knowledge. Three reflection notes were specifically designed to promote establishing a knowledge community across classrooms, and required students to reflect on the quality of their contributions to the group, group dynamics, knowledge co-construction, scientific depth of co-constructed knowledge; and opportunities for reusing and/or improving existing knowledge base.

Data sources included all revisions of purposefully selected Drupal pages, pre-unit and post-unit questionnaires, and curriculum documents. Data analysis was conducted to: (A)Investigate distributed participation in knowledge co-construction by: (1) Contributing knowledge objects, and (2) Improving the quality of shared knowledge objects.; and (B) Examine the Scientific soundness (Linn, Lee, Tinker, Husic, & Chiu, 2006) and Epistemic complexity and growth of ideas (Hakkarainen, 2003) of shared knowledge.

Table 1: Scaffolds designed for Climate Change curriculum in iteration 2.

Scaffolds / Design Goals	Knowledge community discussion	Planning pages	Page templates	Reflection notes	Peer-review
Distributed cognitive responsibility	X	X		X	X
Deep science connections	X	X	X	X	X

Findings and Conclusion

Contents of Issues pages in iteration 2 showed more knowledge objects of partial and complex knowledge integration type compared to iteration 1. We plotted the ratio of standard deviation to mean for the number edits and the number of regulatory messages in each of the 14 Issues group. 11 groups had low to mid levels of dispersion in those measures, suggesting that group members participated in knowledge co-construction more equitably. An 80% increase in the amount of collaboratively edited knowledge-objects suggested that the co-designed curriculum for iteration 2 was successful in addressing the issue of distributed cognitive responsibility.

To further investigate the use of scaffolds, we selected two Issues groups: Deforestation group with less equitable participation among group members and Ocean Warming group, with more equitable participation among group members. Students in the Ocean Warming group used their planning page more effectively to plan for and conduct their inquiry. All but one student in this group accomplished their assigned tasks, whether the task was self-assigned or assigned by other group members. In the Deforestation group, students in each class section created a separate planning page and never merged them together. Regardless, they co-constructed content in their inquiry page spontaneously and did not use either of the planning pages.

One reflection question asked the students to comment on the scientific quality of their contributions. Using the number of words each member contributed towards factual or explanatory content, we identified students with lower quality contributions. One such student from Deforestation group wrote this reflection note: "My group-mates contributions to the issues page were better than mine because my contributions were mildly non-existent." While this reflective note showed self-awareness of the low quality of the student's contribution, none of the students who submitted similar answers to this question improved the quality of their contributions over time. Communicating the need for improving contributions remained implicit.

Our results suggest that with frequent epistemological treatment, such as reflective notes, it is possible to raise students' awareness of the quality and quantity of their work even when roles and the amount of work are not micro scripted. However, to increase their effect, these scaffolds could be complemented with group-level follow ups and with in-time teacher feedback.

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