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Computer-Supported Collaborative Argumentation with Automated Assessment for Science Learning

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KEY IMPLICATIONS

- Science educators need to consider shifting from focusing on exploration and experiment to the construction of argument and explanation.
- The Funnel Model can be used to script collaborative learning activities in classrooms.
- Artificial Intelligence (AI)-enabled learning analytics and assessment could inform teachers and students about the learning progress. It facilitates reflective learning and self-directed learning.

BACKGROUND

In recent years there is a shift in science education from focusing on exploration and experiment to the construction of argument and explanation. Argumentation is part of the practice of science for evaluating, refining and establishing new theories. Much of effective argumentation happens between multiple participants who engage in evaluation, reflection, reasoning, and decision-making through arguments and counterarguments in relation to a specific scientific topic. However, collaborative argumentation rarely takes place in science classrooms. One of the critical issues is that teachers and students lack technological and pedagogical support in designing, implementing, evaluating and reflecting the scientific argumentation.

FOCUS OF STUDY

The research project has developed AppleTree, a system to support students' collaborative argumentation in classrooms. ***AppleTree*** is an abbreviation for "**A**ssessing **P**rocesses and **P**roducts for **L**earning by **T**racking and **R**eporting **E**fficacy and **E**ffectiveness of Collaborative Idea Improvement". AppleTree supports students' collaborative argumentation with graph-based (instead of text-based) representations of argumentation (see Figure 1 for the user interface). It incorporates mechanisms for scripting collaborative argumentation and supporting real-time formative (diagnostic) learning analytics and assessment that enhance the process and outcome of collaborative argumentation to improve students' science learning and cultivate students' 21st Century competencies such as collaborative learning and critical thinking.

AppleTree embeds a pedagogical model called Funnel Model (Figure 2) to script the design and implementation of collaborative argumentation activities in classrooms. By respecting and encouraging cognitive diversity, the first phase encourages the creation of diverse ideas. The subsequent phases tap on this diversity to seek a synergy of ideas, and a phase of convergence and consensus seeking leading to knowledge convergence and advancement of the individuals, groups and class. Through this process, students achieve collective knowledge

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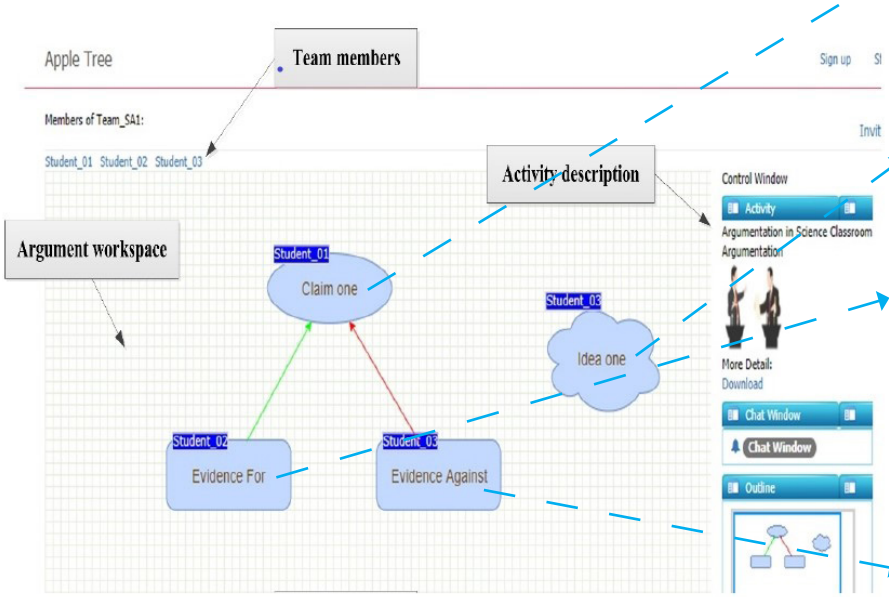

Claim: an assertion, conclusion, statement, explanation, or any answers, about a question.

Idea: an immature point of view, which may become a claim, or turn into an evidence later.

Evidence for: to support the claim. The evidence may come from student's experience, hands-on experiments, previous experimental results, or theoretical principles.

Evidence against: The evidence may come from student's experience, hands-on experiments, previous experimental results, or theoretical principles.

Figure 1. The screenshot of AppleTree System

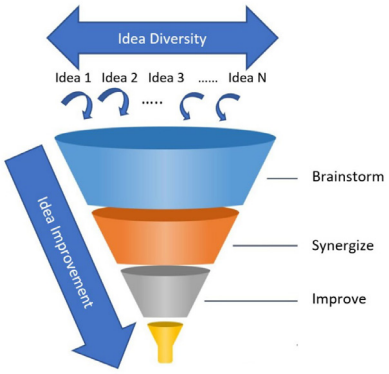

Figure 2. Funnel Model

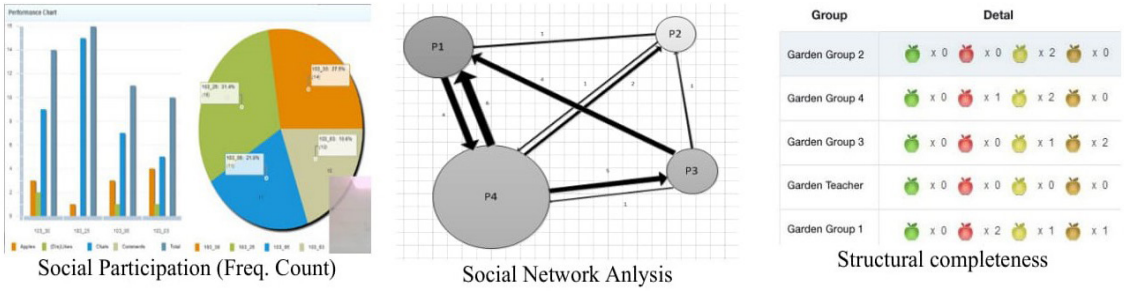

Figure 3. Automated assessment, and visualization generated by *AppleTree*

advancement by having a smaller number of but higher quality of ideas beginning with brainstorming and a structured process of constant knowledge improvement.

AppleTree provides real-time learning analytics and assessment of students' collaborative argumentation. The automated assessment includes the individual student's performance in the group and the group's performance in the class. The real-time assessment allows teachers and students to have a quick evaluation and reflection of their collaborative argumentation process and outcome from the aspects of social participation and cognitive quality (structure completeness) across all the phases of collaborative argumentation activities. Figure 3 shows the visualizations of some automated learning analytics and assessment.

KEY FINDINGS

All the research participants used AppleTree for collaborative argumentation for at least three science lessons. Pre-tests and post-tests were conducted for each cycle of all classes that participated in the design-based research. The Wilcoxon signed-rank test results show that scripted collaborative argumentation with automated assessment improved students content knowledge. Content analysis was employed to analyze the quality of the student groups' artifacts at three phases of Funnel Model. The results show that the quality of students' collaborative argumentation artifacts in later phases were significantly higher than the artefacts in former phases. The pre-intervention survey and post-intervention survey and interview analyses results show that students had significantly improved their attitudes towards science learning and collaborative learning after the research intervention.

Engaging students in collaborative argumentation both increased students' learning motivation and created opportunities for students to restructure their conceptual knowledge. Students were actively engaged in collaborative learning and decision-making processes. More importantly, students' cognitive and metacognitive abilities were developed in the process of communicating, debating, and critiquing one another's argument.

SIGNIFICANCE OF FINDINGS

Implications for practice

Engaging students in scripted computer-supported collaborative argumentation and assessment practices helps them develop scientific literacy – a scientific attitude or habit of mind, and 21st century competencies.

Implications for policy and research

More projects are needed to improve the existing traditional practices of science learning into 21st century science teaching and learning.

Learning gains (for studies involving intervention)

Technology-enhanced learning, learning analytics, automated assessment and AI for education are important research areas.

Proposed follow-up activities

When more students-generated data are available, advanced AI techniques such as machine learning could be used for the automated assessment for the logical reasoning of the argument artefacts.

PARTICIPANTS

One secondary school and one primary school participated in the project. Two physics teachers and two Secondary 3 classes from the secondary school participated in three cycles of design-based research. One physics class had 27 girls and the other had 30 girls. All the students in the school had a personal iPad each. The research intervention was held at the school's science lab. All the students brought their own iPad to do collaborative argumentation.

In the primary school, three science teachers and two Primary 5 classes participated in the research project. These two were mixed ability classes. The size for both classes was 30.

RESEARCH DESIGN

This research employed the design-based research approach to address complex problems in authentic contexts. Researchers and practitioners worked closely in designing the lessons by integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems.

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