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Assessing Processes and Products for LEarning (APPLE) of Collaborative Argumentation

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Abstract: In the realm of CSCL research, collaborative argumentation is regarded as a key type of knowledge construction process that should be mastered by students to enable knowledge advancement. We designed an automated assessment system to support students' collaborative argumentation in Science learning. This paper describes the conceptual framework, the pedagogical and technological design of the system.

Keywords: collaborative argumentation; assessment for learning; automated assessment

1. Introduction

There is an ever-increasing need to provide students with learning experiences that reflect the challenges and opportunities they will experience in the workforce of the 21st century. The key classes of workforce skills relate to critical and inventive thinking and information and communication skills that can be developed through participating in collaborative argumentation. For both individuals and groups, the ability to evaluate and reflect on arguments and counter-arguments in relation to specific issues is critical as it enables sound reasoning, decision making, and task performance (Nussbaum, 2008). Argumentation is also an effective approach to learning as it promotes conceptual understanding and deeper learning of content (Nussbaum, 2008) and enhances knowledge creation (Erduran, Simon, & Osborne, 2003). There have been increasing practices engaging argumentation to teach various subjects (e.g., science: Driver, Newton, & Osborne, 2000; mathematics: Lampert, Rittenhouse, & Crumbaugh, 1996; social studies: de La Paz, 2005), all producing positive results.

Understanding the significance of both "learning to argue" and "arguing to learn" (Scheuer, et al., 2010) to the development of 21st century skills (particularly critical and inventive thinking) and domain knowledge in students, researchers have developed a good number of computer-based systems to support argumentation in the collaborative fashion, to facilitate communication and argumentation between multiple participants (Scheuer, et al., 2010). With the recognition that there is little consensus on assessment practices, the present project aims to develop an assessment-oriented collaborative argumentation system called "AppleTree" for measuring collaboration and argumentation in real classrooms. Apples are fruits of wisdom. Inspired by the "three apples" (Apples in Eden, Apple fallen on Newton's head, and Steve Job's Apple) that have changed human life so dramatically, we hope our AppleTree, an innovative work that is built on existing systems for collaborative argumentation and automated assessment of collaborative learning, can make a difference to existing school practices after iterative cycles of validation in Singapore educational context.

2. Design Rationale

The assessment we proposed for AppleTree is the assessment *for* learning instead of assessment *of* learning. Assessment *for* learning is using multiple forms of information about students' learning as feedback to modify the learning activities they are engaged in, and assessment *of* learning is establishing what students have learnt in a summative way (Shepard, 2000). As indicated in previous research, the roles of assessment in scaffolding learning are well known (Bransford et al., 1999; Shepard, 2000) and computer-based assessment tools that can provide semi-automatic or automatic analyses and diagnosis of online discussions to better scaffold learning are increasingly developed.

White and Fredericksen (1998) tried to make scientific inquiry accessible towards learners through embedding assessment in the design and development of ThinkerTools. ThinkerTools includes a set of assessment criteria to help participants to reflect on their inquiry discourse and communication. In such kind of "reflective assessment", students constantly evaluate their own and other's work. In some studies on knowledge building, researchers employed electronic portfolio notes in Knowledge Forum for formative assessment, and their findings show that portfolio scores can make a significant contribution to conceptual understanding scores (Lee, Chan, & van Aalst, 2006; van Aalst & Chan, 2007). Enlightened and encouraged by these work, we believe via incorporating mechanisms for supporting formative (diagnostic) and automated assessment of the on-going collaborative argumentation process, AppleTree can empower the regulation of collaboration, that is taking actions "on the fly" (immediate adaptations) when unexpected events occur based on a quick appraisal of the current learning status and its compatibility with the desired, to foster productive learning (Jermann & Dillengourg, 2008). During this process, student collaborative argumentation is enhanced and teacher instruction is optimized.

We are attempting to develop automated assessment components that can assess both the cognitive and the social aspects of collaborative argumentation. Cognitive aspect of collaborative argumentation is the ability to construct, evaluate and reflect on arguments and counter-arguments is critical as it enables sound reasoning, decision making and task performance (Nussbaum, 2008). In this study the cognitive aspect of collaborative argumentation is about the construction of sound and syntactically valid arguments which can be measured by the structure and content validity of the represented argument. Social aspect of collaborative argumentation in informed by Wenger's theory (1998) which has been widely acknowledged that participation in collaborative learning in a CSCL learning environment can enhance participants' learning (Prinsen, Volman, & Terwel, 2007; Sorensen, Takle, & Moser, 2006). However, knowledge on how participation in online environment contributes to learning is lacking. With the assessment components proposed, we can understand this issue by identifying collaborative patterns that can bring about improvement in argumentation via iterative cycles of use. In this study, social aspect of collaborative argumentation is about students' participation and online-based communication for constructing the represented argumentation. The behavioral indicators of these 2 aspects of assessment will be discussed in section below with detailed instrumentation described. The key elements of AppleTree assessment are:

1) It supports assessment ***for*** learning rather than assessment ***of*** learning.
2) It assesses argumentation and collaboration at ***individual*** and ***group*** level respectively.
3) It is not only an ***assessment*** tool, but also a tool for visually ***representing*** learning processes unfolding in classrooms.
4) It not only assesses the learning ***outcomes*** but also helps tracking and monitoring the ***process*** of collaboration and argumentation.
5) It involves both ***self-assessment*** and ***peer assessment*** by the students.
6) It is a ***real-time*** assessment tool which provides immediate feedback to teachers and students with which they can adjust or improvise teaching and/or learning, as well as 'feed forward' into future work.

3. System Design

AppleTree is envisaged as a multiuser tool for developing scientific argumentation skills and collaboration skills in secondary school students. Like most collaborative argumentation systems, its user interface provides students with a shared and synchronized working space for collaborative construction of arguments and a chatting tool for communication and coordinating group work (Figure 1). Collaboration scripts are embedded in the system design to empower effective teaching and learning. Real-time visualizations and evaluations of students' social participation and argument construction at different learning stages are displayed to scaffold the argumentation processes and to inspire reflections on both individual and group work.

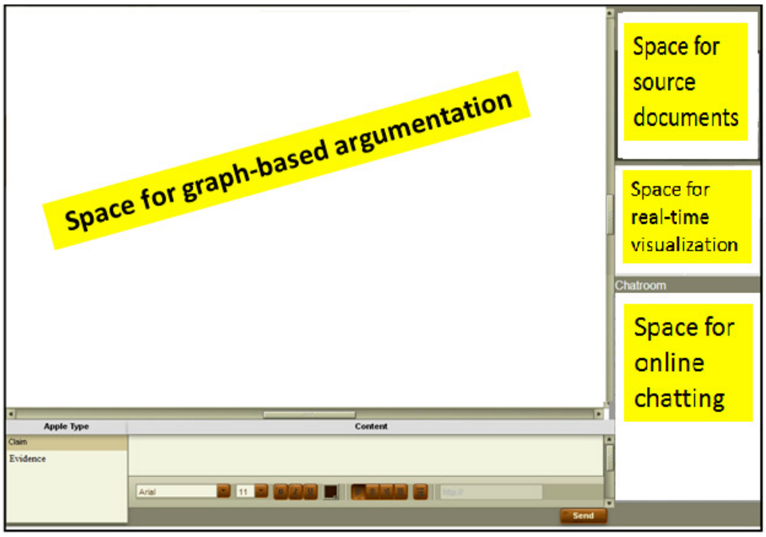


Figure 1. AppleTree user interface

3.1 Argument pattern and representation

For argumentation systems, providing an external representation to enable the creation, reviewing and modification of arguments by users is an important goal (Scheuer, et al., 2010). Compared to linear texts, graphic representation has been shown as being able to induce better learning outcomes (Suthers, et al., 2001) as it expresses the argument structure explicitly and is an intuitive form to model knowledge. AppleTree uses graphic representations. The specific types of argument elements designed are in accordance with Toulmin's Argumentation Pattern (TAP) (1958). In AppleTree, three argument elements, namely claim, support (including data, warrant, or backing) and rebuttal are identified as the essential components of an ideal argument. On an AppleTree implementation, these three elements are indicated by: 1) the type of Node: Claim vs Evidence and/or 2) the type of directed Link: For vs Against (Table 1). Following this, a claim is represented by a "***Claim***" node without any link; a "***Support***" is represented by an "Evidence" node with a "For" link; and a "***Rebuttal***" is represented by an "Evidence" node with an "Against" link. In constructing an argument, a student first chooses the type of argument element and then inputs the content. In the following, the student connects the element crafted to the shared argumentation graph.

Table 1. Argument elements and examples

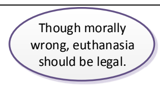
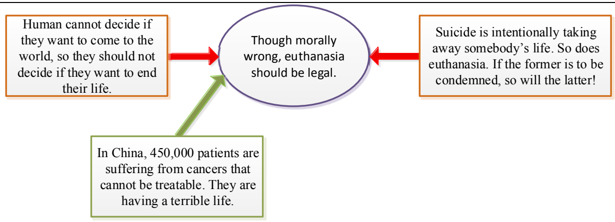
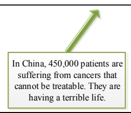
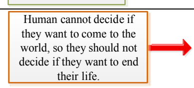
Argument Element	**Textual representation**	**Graphic Representation**	**Example of an Argument**
Claim	Claim		
Support	Evidence +For		
Rebuttal	Evidence +Against		

Figure 2 presents an example of argument representation on AppleTree (simulated data concerning whether euthanasia should be legalized was used).

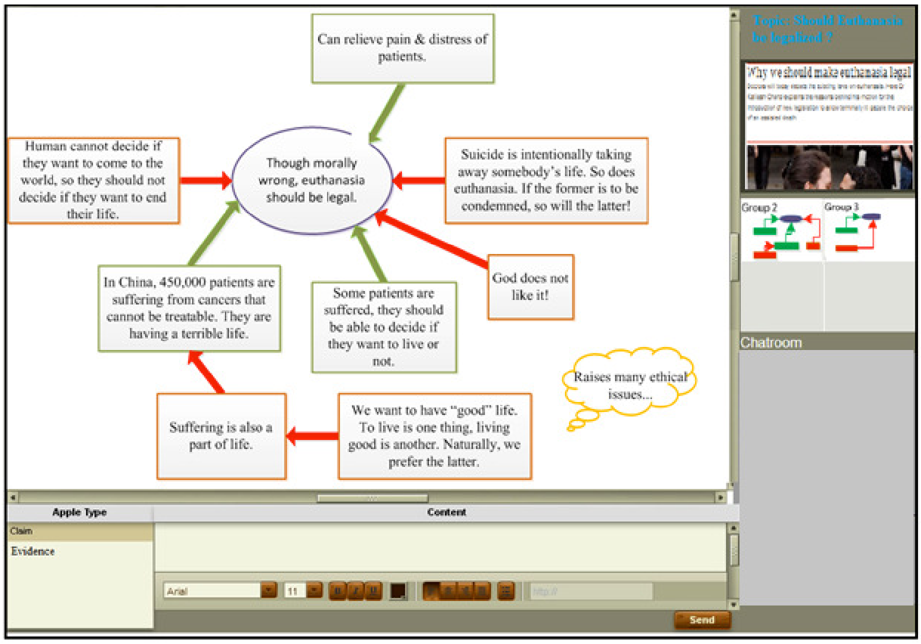


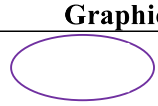
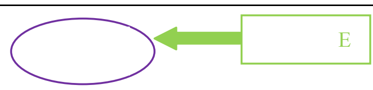
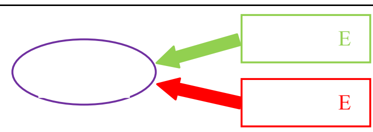
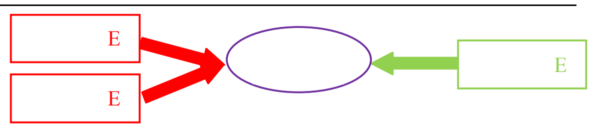
Figure 2. Argument representation on AppleTree (using simulated data)

3.2 AppleTree-supported automated assessment

3.2.1 Cognitive aspect of assessment

AppleTree supports on-going and automated analysis and evaluation of the quality of argumentation unfolding in collaborative work. As reflected in literature, the arguments constructed by effective arguers are of both structural completeness and valid content. Thus, in AppleTree, the assessment of group argumentation quality is measured by structural completeness which refers to constructing arguments with a complete structure, i.e. with all the essential argument components (e.g. claim and evidence) that are critical to effective argumentation. In this project, an argument that is complete in structural is composed of a claim, supporting evidence and rebuttal. Table 2 presents the coding scheme developed for assessing argument structural completeness.

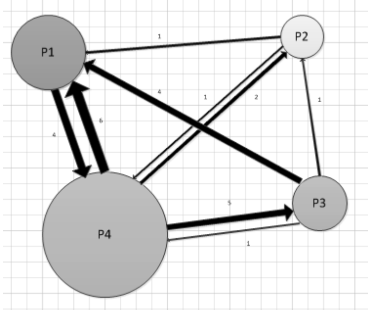
Table 2.Coding scheme for argument structural completeness

Level	Description	Graphic representation (examples)
1	An argument that only contains a claim.	
2	An argument that contains a claim and support (s).	 E
3	An argument that contains a claim, support (s) and one rebuttal.	 E E
4	An argument that contains a claim, support (s), and more than one rebuttal.	 E E E

3.2.2 *Social aspect of assessment*

Social network analysis (SNA) is a well-known approach to investigate online social participation and is embedded in AppleTree. SNA can help identifying patterns of relationship between participants and visualizing the "flow" of information/knowledge and/or other resources that are exchanged among participations (de Laat, et. al., 2007; Haythornthwaite, 2002). In AppleTree, the analysis of the social network established focuses on "***centrality***" and "***density***".

The "***density***" of a network is defined as the number of links in a network divided by the maximum number of all possible links (Scott, 1991). It varies between 0 and 100%. For example, in a network of a class of 40 participants, the maximum number of all possible links (connections) is 780 (40x39/2). "***Centrality***" is also an important indicator for social participation in as it informs the extent to which an individual interacts with other members in the network (Wasserman & Faust, 1997). Using this measure, we can uncover who is the dominant participant in the group or which group interacts most frequently with other groups.



Legend:
- Node (vertex) size refers to the in-degree centrality of each users (bigger node have higher out-degree centrality);
- Node (vertex) color refers to the out-degree centrality (the darker have a higher in-degree value);
- Link width refers to the frequency of reply.
- Link direct refers to "build on" or "reply to"

Figure 3. An example of social network representation

4. Conclusion

In summary, the main benefits of AppleTree include:
1) Providing a generic collaborative argumentation tool that can be used across classrooms, grades, curricula and subject areas.
2) Visualizing continuously the collaborative argumentation process unfolding or happening in classrooms.
3) Defining specific metrics for measuring collaborative argumentation progress.
4) Minimizing the use of classroom instructional time for doing explicit assessment.
5) Supporting teacher professional development by providing a common language to discuss teaching and assessment practices and articulating the mechanism and parameters for assessment of collaborative argumentation.
6) Inspiring and enabling reflection on teaching practices with regard to how it helps equipping students with 21^{st}-century skills.

References

Boud, D. (1995). *Enhancing learning through self assessment*. London: Kogan Page.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience and school*. Washington, DC: National Research Council.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences, 2*(2), 141-178.

Carless, D. (2002). The 'mini-viva' as a tool to enhance assessment for learning. *Assessment and Evaluation in Higher Education, 27*(4), 353-363.

Chan, C. K. K. (2011). Bridging research and practice: Implementing and sustaining knowledge building in Hong Kong classrooms. *International Journal of Computer-Supported Collaborative Learning, 6*, 147-186.

Chung, G. K. W. K., O'Neil, H. F., Jr., & Herl, H. E. (1999). The use of computer based collaborative knowledge mapping to measure team processes and team outcomes. *Computers in Human Behavior, 15*(3-4), 463-494.

Collins, A. (1992). Toward a Design Science of Education. In E. Lagemann and L. Shulman (Eds.), *New directions in educational technology* (pp. 15-22). Berlin: Springer.
Collins, A., Joseph, D., & Bielaczyc, K. (1992). Design Research: Theoretical and Methodological Issues. *Design*, *13*(1), 15-42.
de La Paz, S. (2005). Effects of historical reasoning instruction and writing strategy mastery in culturally and academically diverse middle school classrooms. *Journal of Educational Psychology, 97*, 139–156.
Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*, 287–312.
Elias, T. (2011). Learning Analytics: Definitions, Processes and Potential. Retrieved from http://learninganalytics.net/LearningAnalyticsDefinitionsProcessesPotential.pdf
Gibbs, G. & Simpson, C. (2004). Conditions under which assessment supports students' learning. *Learning and Teaching in Higher Education, 1*, 3-31. Retrieved from: http://www.londonmet.ac.uk/library/r71034_39.pdf
Haythornthwaite, C. (2002). Building social networks via computer networks: Creating and sustaining distributed learning communities. In K. A. Renninger & W. Shumar (Eds.) *Building virtual communities: Learning and change in cyberspace* (pp. 159–190). Cambridge: Cambridge University Press.
Jermann, P., & Dillenbourg, P. (2008). Group mirrors to support interaction regulation in collaborative problem solving. *Computers & Education*, *51*(1), 279–296. doi:10.1016/j.compedu.2007.05.012
Lampert, M. L., Rittenhouse, P., & Crumbaugh, C. (1996). Agreeing to disagree: Developing sociable mathematical discourse. In D. R. Olson & N. Torrance (Eds.), *Handbook of human development in education* (pp. 731–764). Cambridge, MA: Blackwell.
Lee, E. Y. C., Chan, C. K. K., & van Aalst, J. (2006). Student assessing their own collaborative knowledge building. *International Journal of Computer-Supported Collaborative Learning, 1*, 277–307.
Lipponen, L., Rahikainen, M., Lallimo, J. & Hakkarainen, K. (2001) Analyzing patterns of participation and discourse in elementary students' online science discussion, in: P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds) *European perspectives on computer supported collaborative learning. Proceedings of the First European Conference on Computer supported Collaborative Learning*, pp421-428. Maastricht, University of Maastricht.
Munneke, L., Van Amelsvoort, M., & Andriessen, J. (2003). The role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research, 39*, 113-131.
Nussbaum, E. M. (2008). Collaborative discourse, argumentation, and learning: Preface and literature review. *Contemporary Educational Psychology, 33*(3), 345–359. doi:10.1016/j.cedpsych.2008.06.001.
Prinsen, F., L.L.Volman, M., & Terwel, J. (2007). The influence of learner characteristics on degree and type of participation in a CSCL environment. *British Journal of Educational Technology, 38*(6), 1037-1055.
Scott, J. (1991). *Social network analysis: A handbook*. London: Sage.
Siemens, G. (2012). Learning analytics: Envisioning a research discipline and a domain of practice. 2http://learninganalytics.net/LAK_12_keynote_Siemens.pdf nd International Conference on Learning Analytics & Knowledge, Vancouver, BC, Canada. Retrieved from
Shepard, L. E. (2000). The role of assessment in a learning culture. *Educational Researcher, 29*(7), 1–14.
Sorensen, E. K., Takle, E. S., & Moser, H. M. (2006). knowledge-building quality in online communities of practice: Focusing on learning dialogue. *Studies in Continuing Education, 28*(3), 241-257.
Suthers, D. D., Connelly, J., Lesgold, A., Paolucci, M., Toth, E. E., Toth, J., et al. (2001). Representational and advisory guidance for students learning scientific inquiry. In K. D. Forbus & P. J. Feltovich (Eds.), *Smart machines in education: The coming revolution in educational technology* (pp. 7–35). Menlo Park: AAAI/MIT.
Toulmin, S. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.
van Aalst, J., & Chan, C. K. K. (2007). Student-directed assessment of knowledge building using electronic portfolios. *The Journal of the Learning Sciences, 16*(2), 175-220.
Wasserman, S., & Faust, K. (1997). *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.
White, B. Y., & Fredericksen, J. R. (1998). Inquiry, Modeling and metacognition: Making science accessible to all learners. *Cognition and Instruction, 16*, 3–118.