Knowledge Building in Robotics for Math Education

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Abstract: When integrating robotics into teaching activities, most educators employ Competition-Based Learning (CBL) approach. However, CBL may diminish robotics potential, because competitions may discourage active construction of knowledge and the development of talent by isolating students. In this study, we aim to employ knowledge building pedagogy and technology and explore if and how knowledge building creates an innovation network in robotics.

Introduction

It has been claimed in some studies (e.g., Giannakopoulos, 2009) that Competition Based Learning (CBL) is the most effective way to integrate robotics into subjects such as math and physics. In CBL, students build and program their robots in order to accomplish challenges, beat others and get credit (Kanda, Shimada, & Koizumi, 2012). Although the concept of competition in education is supported by several studies, there are several concerns in regards to competitions in education. One concern is that during competitive activities, communication and helping others is usually minimized because students usually perceive their goals as only being reached if other students fail to achieve their goals (Johnson, Johnson, & Smith, 1991). In fact, the growing emphasis on the final products of competitive activities sometimes leads students to disregard other goals such as groups' interactions, collaboration and a shared vision (Cohen, Brody, & Sapon-Shevin, 2004). One potential solution for this concern is to teach robotics employing collaborative approaches. In this study, we employ knowledge building pedagogy and technology and explore whether knowledge building pedagogy and technology has the potential to create an innovation network in robotics?

Theoretical framework

The 12 Knowledge Building principles frame Knowledge Building as an idea-centered pedagogy with students as epistemic agents, creating knowledge through engaging in complex socio-cognitive interactions in which students create *community knowledge* (Scardamalia & Bereiter, 2006). In this study, we employ Innovation network framework (Gloor, 2006) to explore how students collaborate with each other, and whether an innovation network is formed. Gloor identified three forms of network engagement: (1) Collaborative Innovation Network (COIN)- at the core is a team of self-organized and intrinsically self-motivated people who have a collective vision; (2) Collaborative Learning Network (CLN)- people with shared interests join the core community to discuss new ideas, learn, and apply innovations; (3) Collaborative Interest Network (CIN)- people at the periphery, often lurkers, seemingly share interests but do not contribute content. We may think of these different networks as concentric circles, with a ripple effect from innovative core to the periphery.

Method and plan of analysis

This study explores knowledge work in a Grade 5 class. A total of 24 Grade 5 students attended this study and explored Mathematics topics (e.g., proportion, measurement, patterning) using robotics, employing Knowledge Building pedagogy and technology. Students used Knowledge Forum to share their ideas, ask questions, and discuss their problems with all other students in the community. In order to address the research question, we employed social network analysis to explore whether the three networks identified by Gloor (2006) is formed. The notes posted by students in Knowledge Forum is collected, and the network of writers (who communicated with whom) is created. The measures that are used in this study are betweenness centrality and density. As Gloor (2006) described, a central cluster of people in the network with high density and low betweenness centrality forms a COIN. On the other hand, CLNs and CINs have higher betweenness Centrality and lower density, because "external members are connected only to core team members but not among themselves" (Gloor, 2006, p. 150). Other statistic measures like note reading is used to examine which students form the CLN and which the CIN.

Data analysis and preliminary results

Figure 1.a shows students' contributions network. According to Gloor (2006), a highly connected cluster of people is a strong indicator of the emergence of an innovation team. Considering this criterion, a potential COIN team is identified and shown in Figure 1.b
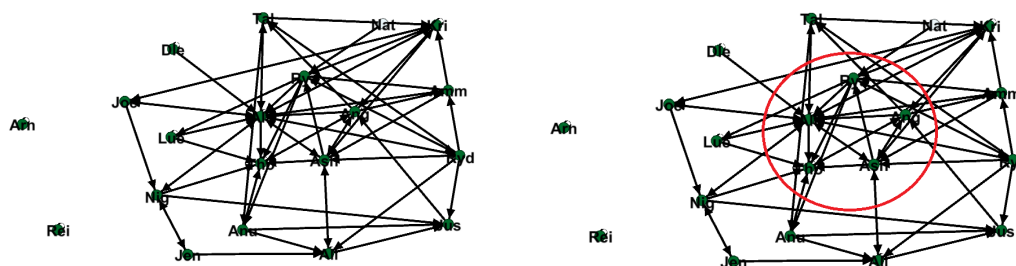
Figure 1. a. Students' contributions network, b. the potential COIN network.

According to Figure 1.b, Alt, Tho, Ash, Ang, Rya are the potential COIN members. To verify the COIN members have been correctly identified, Gloor suggested a COIN network has a high group density and low group betweenness centrality. The results of the SNA show that while the density of the whole network is 0.253, the density of the identified COIN is 1.5, which is in line with Gloor's statement. Also, the group betweenness centrality, as calculated according to Freeman's index, is 0.027536, which is considered low. Therefore, the results of the SNA show the network consists of Alt, Rya, Ash, Ang, and Tho has a high density and low group betweenness centrality, which confirms the emergence of a COIN.

On the other hand, Gloor stated that the CLN and CIN have low density and high group betweenness centrality. The density of the remaining network (i.e., the whole network, excluding the COIN members) calculated as 0.11, and the group betweenness centrality equals to 0.052809. The calculated measures confirm the remaining students form a CLN and a CIN. As stated by Gloor, the CLN members not only -like experts- actively share knowledge but also -like students- actively seek knowledge (Gloor, 2006). On the other hand, while a minority of people in a CIN share knowledge, the majority of them are silent knowledge seekers (lurkers) who do not usually contribute any content (Gloor, 2006). Therefore, students who have posted a reasonable number of notes (i.e., above the average) and have been actively reading notes (i.e. reading the notes more than the average) form the CLN. Using log data and considering the criteria described above, Ryd, Kri, Ali, and Tal form the CLN network. Therefore, the other 14 students form the CIN network. To verify this finding with social network analysis, we have separated the CLN and CIN networks to calculate network density and the group betweenness centrality for each network. The network density of the identified CLN is 0.417 and its Group betweenness centrality equals to 0.046087. On the other hand, the network density of the identified CIN is 0.082 and its betweenness centrality is 0.136361. The results show that both these networks have lower density and higher GBC compare to the COIN, which confirm the CLN and CIN are correctly identified.

Conclusion and discussion

This study was the first attempt to employ knowledge building pedagogy and technology in robotics. The preliminary results show that employing knowledge building pedagogy in robotics creates a community knowledge in which an innovation network is formed. However, not only the emergence of the COIN is important, but also the movement of individuals between networks is important; it is important to have a community in which there are not insiders and outsiders but one where everyone can move between roles of doer, explainer, and critic. For future direction, we aim to conduct such analyses over time and explore how student collaboration patterns change over time, and whether students move from one network to the other two networks.

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