On the Interplay of Social Presence, Idea Improvement and Knowledge Development in Knowledge Building Communities

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Abstract: The results of this research provide an account of advances in foundational knowledge of black-hole physics through analysis of idea improvement and social presence in Grade 12 Knowledge Building classes. The purpose of this study is to collect and analyze student discourse and interactions to uncover socio-cognitive dynamics in an online environment—Knowledge Forum®—designed to support Knowledge Building. Social interactions were quantified within discussion threads using social presence to identify affective, cohesive and interactive markers of engagement. According to expert judgment, students demonstrated impressive levels of understanding black-hole physics while applying Knowledge Building principles to their discourse. Additionally, all markers pointed to one group displaying especially high-levels of collective responsibility for community knowledge. Those results are consistent with the teacher's impression that a *Knowledge Building esprit de corp* characterized the most successful student group.

Introduction

Scardamalia (2002) has argued that knowledge advancement "is in the social fabric of the organization" (p. 8). This statement suggests that organizations such as Knowledge Building communities work best in advancing knowledge and ideas when members of the community attend to both cognitive and social interactions for advancement to occur. Social engagement is an important component for the success of a Knowledge Building activity as evident in the social requirements associated with the twelve principles for Knowledge Building (Scardamalia, 2002). Specific principles that rely on social interactions require students to (i) assume a collective responsibility to share knowledge so as to advance knowledge of the community (ii) practice epistemic agency where participants negotiate the integration of personal ideas and the ideas of others (iii) distributed expertise among the members of the community so that no single person is responsible for producing knowledge (iv) practice Knowledge Building discourse where knowledge is refined and shaped by the social interactions of the community. Specific words such as 'share', 'negotiate', 'distributed' all indicate that knowledge advancement requires productive social interactions if cognitive advances are to occur. Knowledge Building requires a co-occurrence of both social and cognitive components that work in concert to produce knowledge, create ideas and promote idea improvement among community members. This is the essence of collective socio-cognitive responsibility required for Knowledge Building to flourish where members of a community share in the overall advancement of knowledge and idea generation.

I (first author) have been using Knowledge Building as a constructivist learning environment in my classroom for over ten years, primarily in science and physics. The work presented here involves Knowledge Building communities in my grade 12 physics classrooms surrounding topics in modern physics specifically black hole science (no prior scientific knowledge on black hole science is required by the reader to understand the outcomes of this work). While reading the notes posted by my students on this topic, I noticed that my attention gravitated toward one community in particular. Their conversations not only seemed cognitively rich and coherent, but they also attended to each other socially in ways that the other communities under investigation lacked. This one particular community seemed to possess a group 'togetherness' or 'esprit de corps', with discourse seemingly more socially driven and personalized in relation to other communities under similar academic conditions.

A reasonable question is whether heightened social engagement during online discourse - or 'social presence' - imparts cognitive advantages to an online community as a result. Previous research reporting on the interplay between social presence and academic outcomes suggests that this may be the case (Picciano, 2002; Joksimovic et al. 2015). In the work presented here, we investigate whether social presence influences Knowledge Building discourse – specifically in tune with Knowledge Building principles - surrounding two identifiable outcomes found within the discourse threads in Knowledge Forum: knowledge development and idea improvement.

Examining Knowledge Building communities for social presence indicators can indicate the degree to which a community is socially interacting and may subsequently affect educational outcomes such as foundational knowledge development and idea improvement. We seek to answer two questions.

1. Is there evidence of socially supportive online discourse for Knowledge Building communities in courses I have taught? Does one group exceed others in markers of social presence?

2. Is there evidence of idea improvement and knowledge advancement in online discourse for Knowledge Building communities in courses I have taught? Does one group exceed others as measured by various indicators of idea improvement and foundational knowledge advancement?

What is Social Presence?

To examine the social processes surrounding Knowledge Building discourse in this work, I used the lens of social presence to clarify social interactions occurring within Knowledge Building communities in several of my grade 12 physics classes. Social presence was first suggested by Short, Williams, and Christie (1976) as a way to understand how an individual can present themselves as important to others during online discourse where facial expressions and body gestures are absent from view. Within online learning environments, Gunawardena and Zittle (1997) described social presence as "the degree to which a person is perceived as a 'real person' in mediated communication". Being a 'real person' within a computer-mediated community is dependent upon creating an impression or remembrance of oneself while interacting socially either synchronously or asynchronously (Kreijns, Kirschner, Jochems & Van Buuren, 2007). Furthermore, promoting a sense of realness is also dependent upon the style of communication used to project themselves as real (Rourke et al., 1999). Rourke sought to measure this projected realness by looking for social presence indicators found within posted messages that could then be quantified. Clear indicators within messages such as using names, greetings and compliments are viewed as evidence for social presence. Furthermore, members may use non-verbal social cues such as emoticons '☺' and/or expressions of emotion using '!!' that enhance their perception as 'real' people within the community.

Attempts to identify social presence has occurred using self-reporting surveys (Tu, 2002; Gunawardena and Zittle, 1997) and quantified using identifiable markers first described by Walther (1992) then expanded up by Rourke et al. (1999). Rourke conducted content analysis of transcripts to isolate three key categories of responses associated with social presence within an online community: affective, interactive and cohesive responses. Affective responses include those responses that express emotion, feelings and mood. Those would be characterized with the use emoticons, humour and self-disclosure. Interactive responses were identified when group participants were "attending" to others in the group in some identifiable way. Interactive responses saw participants referring to the work of others, quoting directly from others, complimenting and expressing appreciation. Finally, cohesive responses are those that appeared to support and maintain a sense of group togetherness. Table 1 outlines these three categories along with associated indicators within each category.

Table 1: Template for assessment of social presence markers (Rourke et al.,1999).

Category	Indicator	Definition	Example
Affective	Expressions of emotion	Conventional or unconventional expressions of emotion, includes repetitious punctuation, conspicuous capitalization, emoticons	This is cool!! HELLO! :) or :(
	Use of humour	Teasing, cajoling, irony, understatements, sarcasm	'Hey, let's throw Paul into a black hole and see what happens."

	Self-disclosure	Expresses vulnerability, or provides life details outside of classroom experience	"I'm not sure about my answer…" "I'm confused"
Interactive	Continuing a thread	Using the reply feature of software, rather than start a new thread	Software dependent
	Quoting from other's messages	Using software features to quote others entire message or part of a message	Copies and pastes a small section of a larger note
	Referring explicitly to other's messages	Direct references to contents of others' posts	"In your post, you referred to …."
	Asking questions	Students ask questions of other students or the moderator	"Do you think it works this way?"
	Complimenting, expressing appreciation, expressing agreement	Complimenting others or contents of others' messages Expressing agreement with others or content of others' messages	"Nice work everyone!" "That was my thinking exactly" or "I agree with Alex."
Cohesive	Vocatives	Addressing or referring to participants by name	"John mentioned something interesting."
	Addresses or refers to the group using inclusive pronouns	Addresses the group as *we, us, our*	"Our thinking is the same as the researchers."

Table 2 shows an example of how social presence markers were naturally used during Knowledge Building discourse in one of my grade 12 physics classes. In this exchange, we see evidence of affective, interactive, and cohesive indicators expressed throughout the conversation. We see the use of emotion ('!') by both S1 and S2 (notes 6 and 7) and the use of emoticons (':p') by S1 in note 5. We observe complimentary behaviour through appreciation (notes 6 and 8), expressing agreement (note 7), and asking questions to aid understanding (notes 2, 4 and 6). Finally, we see the use of inclusive pronouns (note 8, "*us*" and "*we*") and direct use of names (note 4).

Table 2: A series of notes highlighting examples of social presence indicators. Words in bold represent the scaffolds used in Knowledge Forum.

1. elaboration on neutron stars by S1
Elaboration Neutron stars form when a star with a mass greater than 4 to 8 times the size of our sun goes into supernova, and the result is a core of massively dense material. A neutron star is usually about 20km in diameter and has a mass 1.4 times that of our sun. On earth, a teaspoon of neutron star material would weigh about a billion tons. Neutron stars also have an extremely strong gravitational and magnetic field. Neutron stars are called as such because when the core of the star collapses under its own gravity, protons and electrons combine to make neutrons.

2. where are they now? by S2
I need to understand are these neutrons that are being created by the coming together of the leftover protons and electrons entering the black hole if one if being created or are they being spat back out into the universe for further use?

3. does this help? by S1
My Theory These neutrons are actually what help make up the neutron star. When a neutron star forms, no black hole is formed. The neutron star is made up of the really dense matter partly because of these newly made neutrons.

4. I think so! by S2
Opinion yes thanks [uses S1's name here]. **Evidence** so then in this picture [Figure not shown] the section where [it] says "many neutrons and other particles" is where these neutrons being formed would reside? or is this whole star itself what's being formed?

5. answer by S1
Putting our knowledge together Yes that would be where the neutrons and other particles reside. Keep in mind the neutrons are only formed at the time the neutron star is formed, not after :p

6. tomato analogy by S2
Opinion thanks so much! so the neutrons are formed during the formation of the neutron star so they are just created as a part of it. **Elaboration** kind of like how a tomato is formed with its seeds?

7. exactly! by S1
Opinion Exactly! I may use that analogy later on...

8. yay us! by S2
yay I'm glad we have reached a **Conclusion** - a neutron star is much like a tomato (formation wise of course!)

Examining for Indicators of Social Presence

Three groups of senior physics students - Group A (*N* = 7) Group B (*N* = 5) and Group C (*N* = 6) – were examined for their use of social presence indicators (see Table 1) during their knowledge building discourse in the area of black hole science. Content analysis was conducted on the notes by the first author and subsequent analysis of knowledge development and idea improvement was conducted by experts in the field of black hole science.

The total notes produced in Knowledge Forum by all three groups were analyzed for the ten indicators of social presence shown in Table 1 under the affective, interactive and cohesive categories. The total number of instances of social presence indicators for each category was counted and then divided by the total number of words produced by each group. This quantity is what Rourke (1999) refers to as a social presence "density" whereby the greater the density value the greater the social presence. Social presence density (SPD) is calculated using the following formula.

$$SPD = \frac{Total\ number\ of\ social\ presence\ indicators}{Total\ number\ of\ words} \times 1000$$

Table 3 shows the social presence category scores along with the social presence density score for each group. The numerical values represent the sum of all incidences/1000 words. The results show that the affective, interactive and cohesive categories were highest with Group B followed by Group C finally Group A. A one-way ANOVA ($p < 0.05$) was conducted upon three groups and determined statistically significant differences for social presence among the three groups [$F(2,6) = 10.23$, $p = 0.012$)]. Post hoc comparisons using the Tukey HSD test indicate significant differences between Groups B and C, and Groups B and A. No significant differences were found between Groups C and A.

Table 3: Social presence category scores and social presence density scores (incidences/1000 words).

Category	Group		
	A	B	C
Affective	0.36	7.09	1.31
Interactive	0.31	3.56	0.69
Cohesive	0.16	3.17	0.23
Social Presence Density	0.83	13.82	2.23

Next, a deeper analysis was conducted by comparing individual indicators under each category of social presence as outlined in Table 1. Figure 1 shows the three categories along with the individual indicators for each group. The indicators reported are quantified per 1000 words.

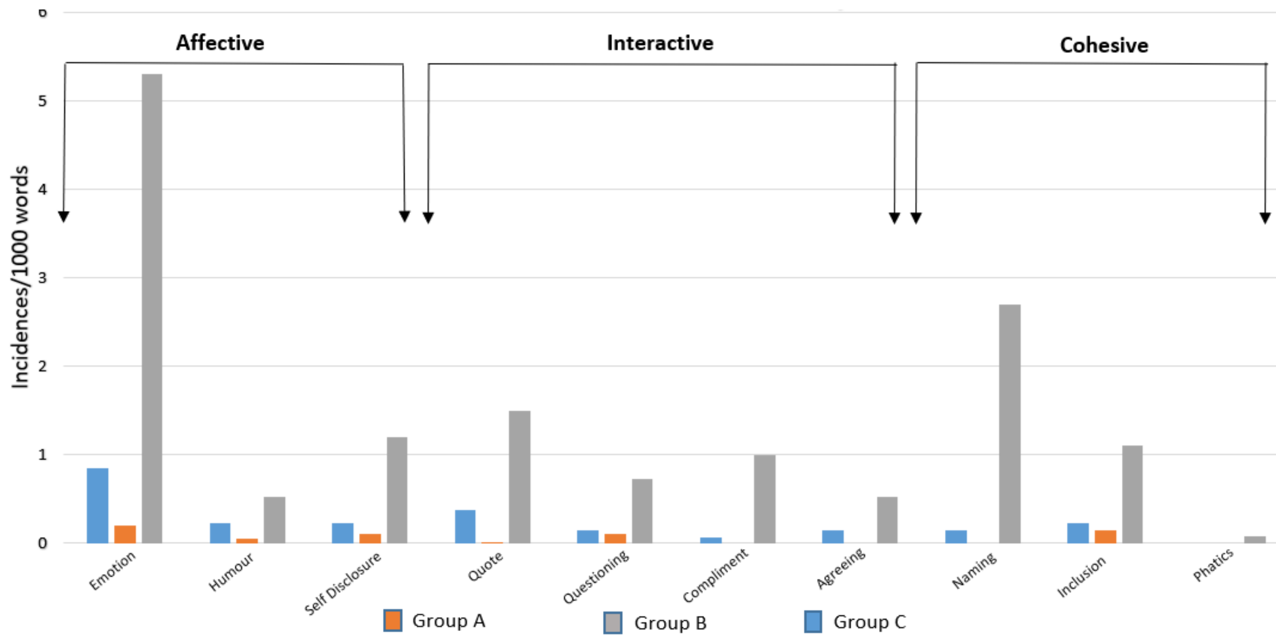

Figure 1. Comparison of individual social presence indicators among Groups A, B, and C.

A one-way ANOVA test ($p < 0.05$) was conduct on the individual indicators shown in Figure 1 under the three categories. The results of the ANOVA test indicate a statistically significant difference in social presence among the individual indicators for the three groups [$F(2,27) = 7.33$, $p = 0.003$]. Post hoc comparisons using the Tukey HSD test indicate significant differences between Groups B and C, and Groups B and A. No significant differences were found between Groups C and A.

Indicators for social presence was found within the discourse of all three groups. However, the data presented indicate a clear distinction between the three groups in terms of their social presence. The community members of Group B present the highest scores on all ten indicators of social presence while Group A showed the lowest. This leads us to ask whether having a comparatively higher social presence density score confers any advantage in terms of knowledge development and idea improvement.

Examining for Knowledge Development and Idea Improvement

Five experts in the field of cosmology volunteered their time to examine a packaged set of notes produced by each group on how black holes are created. Each expert has extensive experience, either through teaching and/or research, in black hole science. Four of the experts hold a Ph.D. in physics. The five experts were given identical sets of notes from each of the three groups to evaluate. The evaluation had the experts look at two areas of interest related to this study: (i) the depth of foundational knowledge developed and (ii) the depth of idea improvement observed. To evaluate the depth of foundational knowledge developed by each group, those experts used the following question to guide their evaluation, '*At the introductory level, how well did the group work to answer the question, 'How is a black hole created?''* The 'introductory level' statement is used to indicate to the experts that the students lacked prior knowledge in black hole science. To judge idea improvement, the experts were given the following statement to help them comprehend the concept: *When working with knowledge, all ideas are treated as improvable. Participants work continuously to improve the quality, coherence and usefulness of ideas presented. Participants recognize what is known and what needs to be known by requesting new information (*e.g., *through question-asking) or clarification on information already presented to the group resulting in conceptual advancement in understanding on the topic discussed.*

Expert evaluation of both knowledge development and idea improvement was conducted using a four-point Likert scale is shown in Tables 4 and 5. Table 4 summarizes the scoring results by each expert in foundational knowledge development showing the individual scores, the average score (*M*) and the standard deviation (*SD*). In answering the question, 'How is a black hole created?' the overall results demonstrated that the Group B produced the highest foundational knowledge score (*M* = 1.80, *SD* = 0.51) followed by the Group C (*M* = 2.60, *SD* = 0.37) and last Group A (*M* = 2.90, *SD* = 0.66). A one-way analysis of variance (ANOVA) was conducted on the foundational knowledge developed by the three groups. The results of the ANOVA ($p < 0.05$) indicate a statistically significant difference between the three groups [$F(2,12) = 4.6$, $p = 0.033$]. Post hoc comparisons using the Tukey HSD test indicate significant differences between Groups B and A. No significant differences were found between Groups C and A or Group C and B.

Table 4: Expert ratings for foundational knowledge development surrounding the question: 'How is a black hole created?' 1 = very complete, 2 = mostly complete, 3 = partially complete, 4 = incomplete.

	Group A	Group B	Group C
Expert A	2	2	2.5
Expert B	2.5	1.5	3
Expert C	3	2	2.5
Expert D	3	2.5	2
Expert E	4	1	3
Average	2.90 (*SD* 0.66)	1.80 (*SD* 0.51)	2.60 (*SD* 0.37)

Table 5 summarizes the scoring results for idea improvement among the three groups for the question, 'How is a black hole created?' Group B achieved the highest idea improvement score (*M* = 1.85, *SD* = 0.89) followed by the Group C (*M* = 2.40, *SD* = 0.49) and finally the Group A (*M* = 4.30, *SD* = 0.40). An ANOVA ($p < 0.05$) was conducted indicating a statistically significant difference between the groups [$F(2,12) = 16.6$, $p = 0.000$] surrounding idea improvement. Post hoc comparisons using the Tukey HSD test indicate significant differences between Groups A and B, and Groups A and C. No significant differences were found between Groups C and B.

Table 5: Expert rating results for idea improvement among Groups A, B and C. 1 = excellent, 2 = very good, 3= good, 4 = fair, 5 = poor.

	Group A	Group B	Group C
Expert A	4	2.5	3
Expert B	4	1	2
Expert C	4.5	1.5	2
Expert D	4	3.25	2
Expert E	5	1	3
Average	4.30 (SD 0.40)	1.85 (SD 0.89)	2.40 (SD 0.49)

Post evaluation interviews were conducted with all the experts to help clarify their scoring and to give feedback on the engagement of each group. For comparison purposes, I contrast the highest-level group B and lowest-level group A. With Group B, experts noted the interplay between foundational knowledge development and idea improvement, the highest scoring group surrounding social presence, knowledge development and idea improvement. Expert B noted the enhanced group dynamic while they tried to understand black hole formation.

> *"Their knowledge generation was primarily through idea improvement. There weren't individuals coming up with a separate chain and trying to progress in that fashion. People weren't presenting their own version of the entire story. People were positing questions…they would very clearly say each time there were things I need to know and I don't understand why this happens. And people would start to answer them. And it's in that answering that they would converge rapidly onto the right answers. They were apparently unafraid to say, 'I don't think that's how it is. I think it is like this'. I would call this excellent."*

Expert C offered this overall impression about Group B hinting at their higher degree of social interaction and esprit de corps as they worked together.

> *"I was more impressed with this group* [Group B] *I'd say, based on ideas and questions asked and then helping to develop and answer those questions. They just seemed more happy, more supportive…"*

Taken together, these experts recognized the advanced social interactions occurring with Group B and their advanced knowledge development and idea improvement co-occurring. Conversely, experts noted Group A did not have as heightened social interactions as that of Group B. Expert B was succinct in his evaluation of idea improvement for this Group A stating,

> *"There is no serious evidence of collaboration. There is not a lot of interaction. I would say it is a rather limited degree of idea improvement."*

Expert E appears to understand how the lack of social engagement within the group has limited Group A's ability to develop knowledge at a much deeper level in understanding black hole formation stating,

> *"I think they should have kept looking back at what their question was. There was nothing wrong on what they said. They did summarize stellar evolution quite nicely. They put down facts but then they really didn't ask themselves 'Ok, do I really understand this, why is it that more massive stars ultimately become black holes?' They tried to answer that a little bit but they certainly didn't go very deep. So part of that is having another group member say 'well ok, thanks for that. Let's go one step further and figure out why some stars go here versus here'. They could have helped each other go a bit deeper."*

Discussion

The first question of this study examined whether there was evidence of socially supportive online discourse among the three groups and whether one group exceeded others in markers of social presence. When the social presence density score was determined for each group, Group B expressed the highest social presence density score compared to the other two groups. Specifically, Group B had the highest expression in the affective, interactive and cohesive categories followed by Group C, then Group A with the lowest scores for all three categories. Conversely, Group A was lowest on all of these dimensions. The contrast in both cognitive and social discourse between Group A and B was identified independently by experts as elaborated in their recorded interviews and independent evaluation of the notes of each group. The experts identified more elements of social presence within the discourse of Group B without being cognizant of these associated indicators particularly those indicators within the interactive category.

The second question examined for idea improvement and knowledge advancement and whether one group exceeded others in these two important areas. When experts examined cognitive work surrounding knowledge development and idea improvement on black hole formation, Group B was unanimously rated as the highest performer for both knowledge development and idea improvement. Of note, the experts independently remarked upon the explanatory discourse of Group B as a primary contributor to their knowledge advancement. These experts noted the social engagement of Group B during the groups' discourse, especially how they helped each other either through question-asking and/or providing explanatory help to advance their cognitive goal of understanding black hole formation. Overall, it was impressive that students in all three groups - using Knowledge Building principles - were able to create and work with questions, knowledge, and ideas within their groups that expert evaluators felt were foundational to black hole formation, despite interesting differences in interactions surrounding idea improvement and knowledge development.

The combined results from the two questions in this study suggests that higher expression of social presence co-occurs with superior production of idea improvement and knowledge development and idea generation. This study indicates that to amplify the cognitive outcomes during Knowledge Building discourse, practitioners of Knowledge Building should attend to the importance that social interactions plays during online discourse, as social negotiations seem to play a significant role in achieving desired cognitive outcomes. Consider the Knowledge Building principle of improvable ideas. The successful execution of this principle within a Knowledge Building community relies on a culture of psychological safety where "people feel safe in taking risks – revealing ignorance, voicing half-baked notions, giving and receiving criticism" (Scardamalia, 2002, p. 9). Social presence seems a proxy for a form of thoughtful, empathetic response that engages participants in working harder—establishing a norm of idea improvement. Social presence in the context of this study opens an important line of future research to examine the interplay between the social and cognitive responsibilities and how they may amplify various Knowledge Building principles that may further enhance knowledge development and idea improvement.

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