Teacher-education students' views about knowledge building theory and practice

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Abstract. This study investigated the effects of engaging students to collectively learn and work with knowledge in a computer-supported collaborative learning environment called Knowledge Forum on their views about knowledge building theory and practice. Participants were 24 teacher-education students who took a required course about theory and practice in teaching. Data mainly came from (1) student discourse recorded in a Knowledge Forum database, (2) a survey that examined students' views about knowledge building, and (3) interviews with regard to students' perceived barriers to implementing knowledge building theory in teaching. Findings suggest that with sustained discourse to construct their collective understanding of the relationships between theory and practice in teaching for a semester, the participants were able to attain more informed and practical views about knowledge building theory. In addition, students' perceived barriers to implementing knowledge building in teaching were identified and strategies to help overcome these barriers discussed.

Introduction

Teaching has been viewed as a craft (Bereiter, 2002). As commonly observed in the classroom, most teachers tend to pursue "best practices" by practicing their teaching according to some known theories, and they are less inclined to go beyond "best practices" and assume the role of theory-building for their practice (Hargreaves, 1999; Sawyer, 2004). Recent literature, however, emphasizes the importance of viewing teaching as a knowledge-building enterprise (Hargreaves, 1999; Zhang, Hong, Teo, Scardamalia & Morley, 2008; Scardamalia, 2002). Related concepts have been introduced to support this idea, for example, creative teaching (Sawyer, 2004), adventurous teaching (Cohen, 1989), and teaching as progressive problem solving (Bereiter & Scardamalia, 1993) or as a sustained design process (Hong, Zhang, Teo, & Scardamalia, 2009). Yet, the idea of education as a progressive science and teaching as knowledge building is still new to most teachers (Sawyer, 2006).

One way to help teachers to develop a deeper conceptual understanding of teaching as a process of knowledge-building may be to engage them in the actual "knowledge-building" practice (Hargreaves, 1999; Hong & Sullivan, 2009). Knowledge-building is a social process focused on the production and continual improvement of ideas of value to a community (Bereiter & Scardamalia, 2003). The epistemological position underlying the knowledge building pedagogy is Popper's (1972) construct of World 3. Other than World 1 (the physical world) and World 2 (the subjective world inside the mind), Popper postulates a World 3 that is constituted of conceptual artifacts. The ideas and theories created by knowledge workers such as scientists, engineers and architects are among the conceptual artifacts. These theories and ideas, once created, have a life of their own in that they can be improved and transformed by people who interact with them. They are treated as tentative theories that should be subjected to error elimination under Popper's schema for the search for truth. In other words, all created knowledge is open to further inquiry and improvement. This epistemological stance is translated directly into the practice of treating all knowledge as ideas and as improvable in a knowledge-building community (Scardamalia, 2002). Bereiter (1994) argues that school focused on changing students' mind (ie, World 2) and neglected the enculturation of students' competencies to work in World 3. Arguably, teachers are unaccustomed to the ways of building knowledge as professionals, much less developing such competencies among students (Hong, Scardamalia, & Zhang, 2007).

To facilitate the process of knowledge building, a set of 12 knowledge-building principles have been conceptualized (Scardamalia, 2002). These principles have evolved over the last two decades: from an earlier focus on transformative discourse (Bereiter & Scardamalia, 1987), intentional learning (Scardamalia & Bereiter, 1991), and creative expertise as progressive problem solving (Bereiter & Scardamalia, 1993), to the most recent 12 knowledge building principles (Scardamalia, 2002). These 12 principles represent some innovative, pedagogical know-how to help transform a traditional class into a knowledge building community. They include (1) *Real Ideas, Authentic Problems*; (2) *Idea Diversity;* (3) *Improvable Ideas*; (4) *Epistemic Agency*; (5) *Community Knowledge, Collective Responsibility;* (6) *Democratizing Knowledge*; (7) *Symmetric Knowledge Advance*; (8) *Pervasive Knowledge Building*; (9) *Constructive Uses of Authoritative Sources*; (10) *Knowledge Building Discourse*; (11) *Concurrent, Embedded, Transformative Assessment*; and (12) *Rise Above* (see

Scardamalia, 2002, for more details). Fundamentally, knowledge building principles are designed to reconceptualize the behaviors of and relationships between three essential knowledge-building entities: the idea, the agent, and the community. For example, the principle of *Real Ideas, Authentic Problems* highlights the importance of viewing student ideas as conceptual artifacts (Bereiter, 2002) that are as real as things touched and felt, and that knowledge problems arise from efforts to understand the world and the ideas of other collaborators in the community, leading to problems of understanding that are quite different from textbook problems and puzzles. The principle of *Epistemic Agency* underscores that participants deal with the full range of knowledge problems (goals, motivation, evaluation, long-range planning, etc.), including knowledge problems normally left to teachers or managers. And the principle of *Community Knowledge, Collective Responsibility* emphasizes that contributions to shared, top-level goals of the community are prized and rewarded as much as individual achievements; team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community. These principles represent design ideals and challenges that set the stage for the community's work in sustained knowledge advancement (Bereiter & Scardamalia, 2003), which is very different from conventional classroom work defined by pre-specified procedures, clear scripts and rules, or any highly-structured, ritualistic learning activities that represent fixed rather than improvable classroom procedures (cf. Hong & Sullivan, 2009).

A growing body of evidence has suggested that it is important to consider teachers' epistemological views since such views will influence classroom performance (Chai, Hong, & Teo, 2009; Pajares, 1992; Richardson, Anders, Tidwell & Lloyd, 1991; Wilson, 1990). The aforementioned principles represent essential concepts underlying knowledge building as a theory of knowing and as a way to transform traditional teaching practice. In order to help prospective teachers develop a more informed view of knowledge building theory and practice, instead of employing traditional direct teaching, the present study engaged the participants in self-initiated and self-directed knowledge work in a knowledge building environment (Hargreaves, 1999; Hong, Zhang, Teo, & Scardamalia, 2009). In particular, we are interested to find out whether knowledge-building environment and technology affects students' learning processes and outcomes. In terms of processes, we looked into participants' online performance patterns, social interaction patterns, and patterns in relation to their reflective understanding of the relationships between theories and practices in teaching. In terms of outcomes, we looked into pre-post changes in students' views about the importance and feasibility of knowledge building, and their perceived barriers to implementing knowledge building in class.

Method

Participants and context

The present research was conducted in a university course titled "Integrating Theory and Practice in Teaching" in Taiwan. The course was offered by the university's Center of Teacher Education to teacher-education students as its last required course before they start their teaching practicum. The university is ranked as one of the best universities in the nation. As such, the students enrolled in the subject university are all academically high-achievers. Based on the test results of the national Basic Competence Test for Senior High School Students (BCTSHSS), in order to enroll in this university, a student's test scores in BCTSHSS need to be ranked above the 95th percentile nationwide. Participants in the present study were 24 teacher-education students (14 females) who were planning to teach at the high-school level in the near future. Their ages range from 21 to 29 (M=24; SD=2.3).

Instructional design and online knowledge building environment

By engaging students in building knowledge in Knowledge Forum, the two main insructional goals were: (1) to help students better understand the complex relationships between theories and practices in teaching; and (2) to help students develop a more informed and practical view about knowledge building. To these ends, an invited talk about knowledge building theory, pedagogy, and principles, and a tutorial workshop about how to use Knowledge Forum for knoweldge building were given in the beginning of the semester. The basic design features and functions of Knowledge Forum were demonstrated to students, for example, how to create a note or a "view" (i.e., virtual spaces for collaborative discourse among community members) and how to "build-on" to an existing note. Other major instructional activities included: (1) a weekly reading assignment in which students (a) reviewed literature related to various teaching theories, and (b) read teachers' interview transcripts in which in-service teachers share their successes and challenges encountered in their daily teaching practice; (2) an invited guest speaker (i.e., a veteran teacher) shared his personal teaching experiences; and, (3) most importantly, sustained online peer discussion about the relationships between theories and practices in teaching.

The technology platform used to support peer discourse is Knowledge Forum--a multimedia community knowledge space (Scardamalia, 2003), in which participants spend extensive time collectively constructing their knowledge. They contribute their ideas in the form of notes. The Knowledge Forum environment also enables

participants to co-author notes, build-on, reference (i.e., citation excepted from other community members' notes), and annotate the work of others, set problem fields and add keywords, and create "rise-above" notes that bring greater coherence to the contents of the knowledge space. All these features are designed as different means to foster collaboration in depth. For example, the "rise-aboves" allow users to gather theories and ideas that have already been presented, synthesize these old ideas and point out new challenges to understandings. Operations such as reading, referencing, editing, rise-above etc. are recorded automatically in the database, and can be summarized statistically by means of an Analytic Toolkit (Burtis, 2002). The Knowledge Forum technology designs—in line with the overarching commitment to continual knowledge improvement—allow students to exchange ideas and continuously improve them.

Study design and data sources

This research employed a mixed-method design. The rationale for using such a design is that "the quantitative data and results provide a general picture of the research problem; more analysis, specifically through qualitative data collection, is needed to refine, extend, or explain the general picture" (Creswell, 2005, p. 515). Data sources mainly came from: (1) students' online discourse which was recorded as notes in a Knowledge Forum database, (2) a survey, and (3) interviews. We describe each in detail below. First, a descriptive analysis and a social network analysis (SNA) were performed on the recorded dataset in the Knowledge Forum to describe in general the overall online knowledge building process. In addition, all notes in the Knowledge Forum database were content-analyzed to examine if students gained a deeper understanding of the relationships between theories and practices in teaching. To do so, an open-coding procedure (Strauss & Corbin, 1990), using the note as the unit of analysis, was adopted. A two-level coding scheme based on Anderson & Krathwohl's (2001) revision of Bloom's (1956) Taxonomy of Educational Objectives was adopted. The two levels are: (1) lower-level cognitive activity/responsibility (including remember, understand, apply teaching theories), and (2) higher-level cognitive activity/responsibility (including analyze, evaluate, and create teaching theories). Two researchers repeatedly read and re-read all students' notes and then categorized each note into a level. An inter-coder agreement was computed to be 0.89 (with all differences resolved by discussion). Table 1 shows the coding scheme. To determine whether there were any changes in terms of students' discoure levels, the whole semester was divided into two stages: an early and a later knowelge-building stage (using the midterm exam as a point of seperation). A Chi-square was computed to decide if there were any differences between the two stages in terms of the discoure levels.

Second, a survey that measures students' views about the importance and feasibility of knowledge building was administered in the beginning and at the end of the semester as a pre-post assessment. This survey was designed by the authors to assess participants' mindset about the importance and feasibility of knowledge-building. There are 12 items in this survey, each is represented by a knowledge-building principle (see Scardamalia, 2002, for details). Using subjects (N=22) from another teacher education program of a comparable university, the Cronbach Alpha reliability estimates were calculated to be .87 (for the "importance" dimension) and .74 (for the "applicability" dimension). All items in both surveys employed a 5-point Likert scale (1=strongly disagree; 5=strongly agree). T-tests were conducted to see if there were pre-post changes in students' views.

Third, an approximately one-hour long interview was conducted as a follow-up investigation to further explore the perceived barriers and challenges among the teacher-education students who have expressed concerns about implementing knoweldge building in their future teaching. Six (out of total 24) participants who rated knowelge building as important but less feasible in their surveys were approached and they agreed to participate in the follow-up interviews. The interview data were transcribed verbatim and qualitatively used to help uncover some major barriers to implementing knowledge building.

Table 1. Coding scheme for analyzing relationships between theory and practice in teaching

Level	Focus	Description	Example (Translated from Chinese)
Lower-level cognitive activity/ responsibility	Remember/ understand	Teachers should know and understand theories;	Teacher should understand some basic theories, such as behavioral learning and collaborative Learning.
	Apply	Teachers should be able to apply theories in teaching	I think teachers need to apply different theories in different conditions.
Higher-level cognitive activity/ responsibility	Analyze/ Evaluate	Teachers should be able to analyze theories and practice	Experience and theory are like Na-Kon-Hsin-Fa [a type of Chinese Kung Fu]. After one masters some theories, they can help supplement and/or be integrated into one's own personal teaching experience.

Create	Teachers should be able to improve and even create theories	Teacher's experiences and self-reflection can help with the development of new theories.

Results and Discussion

Knowledge building practices

Online contribution patterns

The overall online activity and performance in this community is shown in Table 2. Throughout the whole semester, the participants contributed a total number of 625 notes with a mean number of 26.04 (SD=6.69) notes being generated per person. In addition, Table 2 also shows other related online knowledge-building measures recorded in this community, including number of note revisions, number of keywords in notes, and number of build-on notes generated, and number of rise-above notes created. Overall, the online activities were substantive as compared with our previous study (see, Hong & Lin, accepted; Chai & Khine, 2006). Nevertheless, while these behavioral measures gave a general picture of how participants worked online in this database, they do not tell much about how participants actually interacted with one another. To better understand the social dynamics in the community, a social network analysis (SNA) focusing on network density was conducted.

Table 2. Descriptive analysis on individual online knowledge-building activities

Online activity	Mean	SD
No. of notes created	26.04	6.69
No. of note revisions	8.5	7.0
No. of keywords in notes	6.6	4.21
No. of build-on notes created	10.2	4.45
No. of Rise-above notes created	1.1	0.81

Online interaction patterns

SNA was conducted to investigate interaction patterns in the community by using the automatic assessment tools embedded in the Knowledge Forum. Table 3 shows the overall interactive and collaborative patterns in the community throughout the whole semester, using two indicators that are available in the Knowledge Forum: passive "note-reading" and active "note-linking" (including build-on notes, references, and annotations). It also shows detailed results of participants' interactions in two knowledge-building stages (using the mid-term exam as a point of seperation). In this particular analysis, density is defined as the proportion of connections in a network relative to the total number possible. The higher the number of the density is, the stronger the social dynamics of a community is implied. An intention of adopting the knowledge-building practice in this course was to transform the traditional knowledge-transmission mode of learning into a knowledge-construction mode to engage these students in collective problem-solving and knowledge work. Therefore, it was expected that the students should collaborate more as they progress. As can be seen, there was an increasing trend of social interactions as reflected by the measures of density recorded online for this community from the early to the later knowledge building stages, especially in terms of note-linking (which inlcude build-on, reference, and annotation). Lipponen Rahikainen, Lallimo, and Hakkarainen (2003) regarded a social network density of .39 for students building-on each other online messages as adequate. In this study, the social network density for building-on at the end of course is 44.2%. The findings indicate a satisfactory level of social interaction in this community.

To further understand the quality of learning in this community, we content-analyzed students' notes. In so doing, we illustrate the processes of how they actually learn and deepen their understanding towards the pre-determined teaching goal, which was to better understand the relationships between theories and practices in teaching.

Table 3. Social network analysis (SNA) of interactivity in this community

Network density	Early KB stage	Later KB stage	Whole semester
Note reading	223 (80.79%)	223 (80.79%)	276 (100%)
Note linking	47 (17.02%)	130 (47.1%)	143 (51.81%)
Build-on	35 (12.68%)	109 (39.49%)	122 (44.2%)
Reference	16 (5.79%)	15 (5.43%)	30(10.86%)

Annotation	17 (6.15%)	57 (20.65%)	71(25.72%)

Reflective patterns

Table 4 shows how the focus of students' discourse with regard to teachers' cognitive activity/responsibility changed over time from the early to the later knowledge building stages. A Chi-Square test showed a significant difference between the two stages ($\chi^2 = 19.78$, df = 1, $p < .001$). As it shows, at the early KB stage before the midterm, students' online discourse tended to focus more on lower-level cognitive responsibility of teachers, highlighting that teachers only need to understand and appreciate teaching theories, and apply them accordingly in practice. As an example (translated from Chinese), below is a student's online reflection after she read an article about corporal punishment; in her reflection, she basically views theories as authoritative sources for knowledge application:

> The teacher [in the reading materials] expressed her opinions on "education of love" and "corporal punishment". I have no teaching experience, in reality, and therefore am not able to judge which strategy works better. I, however, very much agree with her ideas. "Education of love" certainly could cultivate more independence and autonomy in students, but I also doubt its effectiveness. For those students who appreciate the teacher's encouragement, "education of love" might work well; however, for those who do not care about the teacher's encouragement, "corporal punishment" might not be a bad thing…Nevertheless, I believe that the approach of "education of love" has more benefits than drawbacks…If the teacher can apply the right strategy at the right situation, students will be able to trust him/her.

At the later KB stage, students' online discourse began to focus more on the higher-level cognitive responsibility of teachers, emphasizing that teachers need to improve and even generate their own teaching theories. For example, below is another excerpt from the same student drawn from a note composed at the later knowledge building stage:

> Thank you, those who replied to my note. I am glad to see that we are gradually linking our ideas together. I believe we all think that "a theory needs to be shaped again and again." This is a process and also a procedureof strengthening a theoretical statement. By referring to classmate Hsu's idea, I think theory itself is a conceptual sketch. No matter how it is challenged or shaped by the practice,the sketch will be modified and refined in a better way.

Table 4. Changes in students' understanding of the relationships between theories and practices in teaching

	Lower-level cognitive activity	Higher-level cognitive activity
Early knowledge-building stage	42	9
Later knowledge-building stage	25	36

The above findings suggest that engaging students in knowledge building practice is helpful to gradually promote more reflective discourse among participants and deepen their understanding of the relationship between theory and practice in teaching. Below we examine whether engaging students in knowledge building practice also has any effects on their views about knowledge building theory and practice.

Students' views about knowledge building

Changes in students' perceived importance and feasibility of knowledge building

To further understand if engaging students in knowledge building practice also has impact on their views about the importance and feasbility of knoweldge building, t-tests were conducted. First, in terms of the pre-test, it was found that the teacher-education students tended to consider knowledge building to be both important (M=4.38, SD=0.41) and feasible (M=3.35, SD=0.49) as their means were both higher than the average mean value (M=3.0). To explore futher, however, a paired-sample t-test showed a significant difference between the importance and feasibility of knowledge building (M=1.03; SD=0.68; t=7.41, df=23, $p < .01$), suggesting a perceived discrepancy among the participants (see Table 5). In terms of the post-test, a paired-sample t-test continued to show that there was a significant perceived discrepancy (M=0.79; SD=0.49) between the

importance (M=4.23, SD=0.54) and feasibility (M=3.44, SD=0.44) of knowledge building (t=7.88, df=23, p <.01) at the end of the semester. These findings, however, were quite expected as the participants were teacher-education students who had no prior teaching experience at the time of this study; thus it was natural that they inclined to rate the feasbility lower than the importance, both in terms of pre-test and post-test. Nevertheless, what is more important to know is whether the discrepancy was reduced after engaging students in knoweldge-building practice for a semester. Further t-test indicated there was a marginally significant difference (M=0.24, SD=0.57) between pre-post tests (t=2.02, df=23, p =.055), suggesting that engaging students in knoweldge-building practice did help reduce their perceived discrepancy to some extent.

Table 5. Students' perceived discrepancy between the importance and feasibility of knowledge building

	Difference		t-value	p-value
	M	SD		
Importance-feasibility discrepancy in pre-test	1.028	0.679	7.410	0.000**
Importance-feasibility discrepancy in post-test	0.792	0.492	7.881	0.000**
Reduced discrepancy between pre-post tests	0.236	0.573	2.017	0.055*

* < .10 ** <.01

Perceived barriers to knowledge building

As the above finding suggests, students' perceived feasibility was relatively low as compared with their perceived importance of knowledge building. With this in mind, a relevant question to ask is what might be the barriers to students perceiving knowledge building as feasible? Making these barriers explict is an essential step to addressing them. Our follow-up interviews indicated concerns regarding the aforementioned three knoweldge building entitites (agency, ideas, and community).

Views on student agency. The interview data first revealed teacher-education students' distrust of children as epistemic agents capable of constructing their own knowledge. For exmaple, as one participant commented, "I think it [knowledge building] is less feasible because of age differences. Age differences must be considered. This is especially true for young students. I believe that if they plan their own learning, they will focus on playing." Apparently, this interviewee tends to believe that children are too young to plan and regulate their own learning as an independent knowledge agent. Such beliefs, however, are contrary to previous research findings that suggest knowledge building is possible even among young children such as grade five students (Hong, Scardamalia, Messina, & Teo, 2008; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007). Unfortunately, such disbelief in children's knowledge building capacity does align with conventionally held eudcational beliefs which hold that learning must always come first (e.g., during K-12 schooling), before one can really produce new knowledge (e.g., during graduate study) (cf. Hong & Sullivan, 2009). Under this view, maximizing one's individual knowledge (i.e., seeing knowledge as a psychological state confined within Popper's second World) seems an important criterion in judging whether instruction is effective or not, leaving little room for knowledge-building.

Views on idea-centered learning. The interviewed students were also less in favor of idea-centered learning that highlights the importance of sustained production and improvement of ideas. Instead, they tended to emphasize the importance of accumulating basic knowledge in order to pass exams. As an interviewee commented, "…it [knowledge building] is less feasible because what is taught in school in order to help students pass exams is often not related to the real ideas or authentic problems in life." As another commented, "It is not practical to teach more than one solution to a math problem. For example, in learning math, more than one solution [as opposed to idea diversity] may lead students to confusion, especially when the instructional goal is to help students pass the test." As mentioned above, conventional classroom work tends to be defined by pre-specified procedures, clear scripts and rules, and highly-structured learning activities in order to help learners acquire pre-specified knowledge efficiently and then pass exams. As such, establishing a broader knowledge base becomes much more important as an instructional goal than encouraging students to work innovatively with knowledge and engage in sustained idea production and improvement.

Views on community knowledge. The interview data also showed the future teachers' concern about group equity and social harmony in relation to building community knowledge. For example, a participant commented, "I think people can work together in a group but there will never be equal contribution in a group." As another commented, "You can not make sure everyone will have the same value and share the same responsibility, as each one has his or her own individual learning goal." In other words, they still tend to treat knowledge as individual, rather than public, property. They were also less inclined to accept the concept that to give knowledge is to get knowledge in a knoweldge community. For example, one said, "some members never give/share knowledge, but just take from others. To maintain a good social relationship is a key factor that should be taken into consideration." Perhaps, this is because their past schooling and test-related experiences tend to emphasize individual learning rather than group knowledge work. Clearly, how to help transform these

teacher-education students' individualistic learning view into a view that also appreciates the social aspects of learning remains an important challenge.

Summary and Conclusion

In this exploratory research study, we reported the process of knowledge building among a group of teacher-education students and investigated the effects of this knoweldge building process on their views about knowledge building theory and practice. In summary, it was found that engaging students in knowledge building is helpful to (1) promote gradually more interactive and reflective online knowledge building activities; and (2) to somewhat reduce their perceived discrepancy between the importance and feasibility of knowledge building as a theory of knowing and as a way to transform conventional teaching practice. In addition, a major challenge of implementing knowledge building identified through in-depth interviews among participants who especially rated knowledge building as less feasible was that participants' prior schooling experience and socio-cultural expectations tended to strongly influence how they might interpret and value the feasibility of knowledge building. Overall, these participants' prior epistemic views are still largely confined within Popper's world 2 epistemology which sees knoweldge as psychological entity (as opposed to the concept that sees ideas as public artifacts) and learning as individualistic activities (as opposed to the concept that sees learning as a communal acivity) and as accumulation of authorative knowledge (as opposed to the concept that values self-initiated and self-directed knowledge construction). To help students develop more informed and practical views of knowledge building theory and practice thus implies helping them to develop a world 3 knowledge view that sees knowledge as public conceptual artifacts and learning as a social process (Hong, Scardamalia, & Zhang, 2007).

The instructional goal of the present research was (1) to help better prepare teacher-education students to attain a deeper understanding of the relationships between theory and practice in teaching, and (2) to help them develop more informed views about knowledge building. To further this end, we conjecture that a possible strategy is to make teacher-education students' own pedagogical, epistemological, and socio-cultural views about learning and knowledge-building more visible to themselves. Accordingly, an effective instructional design may be to engage them to discuss more explicitly in class their own views about knowledge-building, while at the same time engaging them in actual knowledge-building practices. It is posited that doing so would further help students clarify their conceptual discrepancies between theories and practices in teaching, and gradually achieve World-3 oriented views and thus be able to see knowledge building as more feasible in reality. It is futher conjectured that after being immersed as a knowledge builder in the teacher education program, it may be beneficial to engage teacher-education students in facilitating knowledge-building communities during their practicum experiences under the guidance of experienced knowledge building teachers (See Chai & Tan, 2009). Given the deeply rooted nature of beliefs highlighted above, it seems clear that a single stand-alone course on knowledge building is unlikely to counter the effects of existing beliefs and views on one's own teaching and learning. These claims, however, remains to be further examined by future research.

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