Effect of Formative Feedback on Enhancing Ways of Contributing to a Explanation-Seeking Dialogue in Grade 2

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Abstract: This research explores the extent to which a new assessments can help students to enhance their ways of contributing to explanation-seeking discourse, and also investigates the extent to which expanding contribution repertoires helps students to advance community knowledge as a whole. To this end, this study tested both pedagogical and technological supports designed to raise the level of students' dialogue. Repeated "meta-discourse sessions" were integrated in students Knowledge Building inquiry as a form of pedaogigical support, and students were also exposed to three forms of automated feedback that included Word Clouds, a "MetaDiscourse" bar graph, and Word Network visualizations that displayed important aspects of their discourse. Results indicate that the MetaDiscourse bar graph is particularly conducive to helping students expand their contribution repertories in targeted areas and that repeated meta-discourse sessions are valuable for aiding students in advancing group knowledge in general.

Introduction

The ability to produce new knowledge can be described as a capacity for "productive work that advances the frontiers of knowledge as these are perceived by [a] community" (Bereiter & Scardamalia, 2003). Increasingly, societal capacity for innovation and the creation of new knowledge is required to address the sorts of complex problems that characterize the 21st century, such as accelerating climate change, widespread financial downturns, and global political unrest (David & Foray, 2003; Homer-Dixon, 2000). The research reported in this study is concerned with increasing society's capacity to create new knowledge by testing educational innovations aimed at enhancing students' abilities to contribute to knowledge creation processes. Given that new knowledge is generated through the discourse that characterizes a particular knowledge community, this study focuses on testing pedagogical and technological supports that can help students expand the ways they contribute to collaborative explanation-seeking discourse.

This research uses a Knowledge Building approach, which is a pedagogy that is uniquely suited to research for developing students' capacity to work creatively with knowledge. Knowledge Building can be described as "*the production and continual improvement of ideas of value to a community*" (Scardamalia & Beretier, 2003, p. 1370). Knowledge Building pedagogy is dedicated to immersing students in a culture of knowledge creation that places the advancement of community knowledge as the explicit and shared goal (Scardamalia & Bereiter, 2003). A key aspect of Knowledge Building is the commitment to engaging students in sustained explanation-seeking or “progressive discourse” (Beretier, 1994), which can be described as collaborative dialogue that advances through continued efforts to deal with puzzling facts. The Knowledge Forum (KF) online environment is the technology that supports the pedagogy. This environment is specially designed to support knowledge creation processes, the emergence of big ideas and principle-based learning (Scardamalia, 2004).

Given that advancing community knowledge is premised on improving the quality of shared discourse (Bereiter, 2010), the questions for educators and researchers working to help build students’ capacities for creating new knowledge ask: how can we boost students’ capacities for “making good moves” in explanation-seeking discourse? How can we help them make diverse contributions that are “on course” and work to advance community knowledge? A growing body of literature shows that a prerequisite for productive collaborative classroom dialogue includes a dynamic interaction of various contributor roles (de Bono, 1985; Anderson, Holland, & Palinscar, 1997; Hogan, 1999; Webb & Mastergeorge, 2003). Similarly, research has shown that an important indicator of productive and progressing explanation-seeking discourse is the presence of diverse contributions to the shared dialogue (van Aalst, Chan, Wan, & Teplovs, 2010; Matsuzawa, Oshima, Oshima, Niihara, & Sakai, 2011; Oshima et al., 2012).

In efforts to identify and chart the particular contribution types that help to carry a knowledge building discourse forward, Authors, (2011a), developed a comprehensive inventory of ways of contributing to explanation-seeking dialogue that charts a range of contribution types one can expect to encounter in the shared discourse of elementary school students. This inventory includes six main contribution types, including “asking thought provoking questions”, “theorizing”, “obtaining information”, ”working with information”, “synthesizing and comparing”, and “supporting discussion”, as well as 24 subcategories corresponding to these main types. Studies that identify meaningful contribution types to collaborative discourse provide a means to assess students’ dialogue and to earmark important contribution types that can serve as targets for innovative design work. For example, using this inventory to explore the work of Knowledge Building students in Grades 1-3, Authors (2011b) identified “asking thought-provoking questions” and “theorizing” as the two main contribute types young students engaged most often in their naturally-occurring work, while “obtaining information”, “working with information” and “synthesizing and comparing” were lacking and thus require additional support. The study reported in this paper builds off of this research by targeting low-level contribution types and testing pedagogical and technological supports geared to help primary aged students expand their ways of contributing to explanation-seeking discourse.

New Assessments for Explanation-Seeking Discourse

With respect to pedagogical supports, this study explores how repeated "meta-discourse" discussions embedded within a Knowledge Building inquiry can help students keep their discourse progressing. "Meta-discourse" can be described as discussion about discussion, and calls for community members to take a "meta-perspective" on their own dialogue. Meta-discourse serves as a type of formative evaluation that can help a knowledge creating community both assess their achievement up to the current point and decide on a future plan of action. In Bereiter and Scardamalia's (2010) structural model of Knowledge Building discourse, "meta-discourse" represents a discourse move that is peripheral to the "central path" of the dialogue and as such, is often neglected in practice (p. 4) and lacking in online discussion (Scardamalia & Bereiter, 2006). However, the benefits of meta-discourse to Knowledge Building work have been repeatedly documented. For instance, van Aalyst (2009) identifies meta-discourse as a key condition of an innovation ecology that can enable knowledge creation. Studies also show that meta-discourse can help students in a range of important ways, such as recognizing shared knowledge advances, identifying setbacks, setting goals, connecting ideas, and articulating new questions (Zhang & Messina 2010; Zhang, Hong, Scardamalia, Teo, & Morley, 2011).

In terms of technological supports, the development of new automated assessments to boost students' capacity to contribute productively to explanation-seeking discourse represents a goal shared by a growing number of research programs (Teplovs, Donoahue, Scardamalia, & Philip, 2007; Van Aalst, et. al, 2010; Yang, van Aalst & Chan, 2012). The study reported here shares this objective, and experiments with automated feedback that helps students get a "bird's eye view" of their own dialogue and that targets both the contribution makeup and content of students' emergent discourse. The feedback supports tested in this study include Word Clouds, a new tool featured in Knowledge Forum called the MetaDiscourse tool (Chen & Resendes, 2012), and Word Network visualizations produced by KBDeX (see Oshima, Oshima, & Matsuzawa, 2012). Each type of feedback is discussed in more detail below:

(a) *The MetaDiscourse tool:* To explore ways to expand students' contribution repertoires using automated feedback, we tested visualizations produced by the "MetaDiscourse" tool. This tool allows students to monitor the types of discursive moves that are being made by their community at any given time (see Figure 1 on next page). The bar graph measures correspond to the verbal scaffolds that are featured in the note interfaces in Knowledge Forum (e.g. "My Theory", or "I need to understand", etc.). These scaffolds underlie important epistemological processes and help to frame students' thinking and encourage contribution types conducive to idea improvement. We choose to use this tool to not only facilitate "meta-discourse sessions" but to help introduce two new scaffolds to students that target low-level contribution types—"This information is important because" and "Our improved theory". The former maps onto the contribution category "obtaining information" and the latter to "synthesizing and comparing", both of which have been identified as contribution types that require extra support in the discourse of primary level students (Chuy et al., 2011).

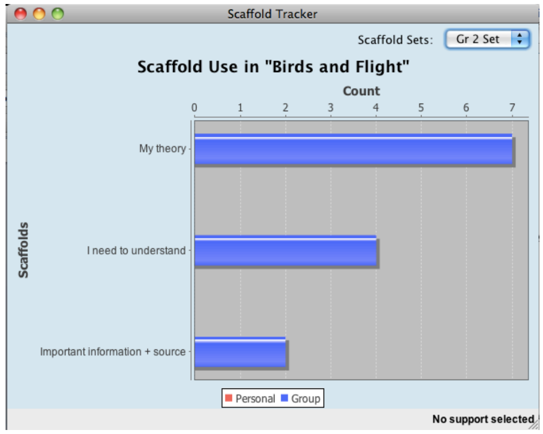

Figure 1. MetaDiscourse tool visualization showing bar graph of scaffold use.

It is important to note here that automated assessments that are built to guide the most important dimensions of Knowledge Building practice visualize data in simple representations that are easy for both students and teachers to use in practice, but are also powerful enough to help boost both the socio-behavioural and cognitive processes necessary for knowledge creation to occur (Yang, van Aalst, & Chan, 2012). The simple graph produced by the MetaDiscourse Tool is accessible to students from a range of ages and provides a simple yet powerful visual to facilitate reflection on important attributes of shared dialogue, for instance, whether a particular discourse is saturated with questions but relatively few ideas, or whether there is an abundance of outside information but no connections between facts and students' own theories. Furthermore, As van Aalyst (2006) points out, it is critical that students possess an understanding the nature of explanation-seeking discourse in order for automated assessments to be meaningfully integrated within the routines of their knowledge building work. The MetaDiscourse tool can help foster deep understanding of the nature of explanation-seeking discourse by presenting group-level data that can be used to initiate and facilitate whole class, reflective discussions about the contribution types that make up the community's discourse at any given time in the inquiry, including why different contribution types might be important at different times. By detecting and displaying contribution patterns, feedback provided by the MetaDiscourse tool can help to highlight underrepresented contribution types and bring neglected elements of the discourse to the forefront of students' attention (Scardamalia, Bransford, Kozam, & Quellmalz, 2012).

(b) *Word Clouds:* To help facilitate meta-discourse discussions, a series of different word clouds were created visualizing key terms and concepts relevant to various streams of inquiry that emerged in students' own discourse. Word clouds refer to representations of textual data that are based on schemes of significance or popularity expressed through visual properties like font size, color, position, or weight (Bateman, Gutwin, & Nacenta, 2008). Word clouds have been shown to be educationally beneficial in a number of ways. For example, Word Clouds can act as "suggestive device[s]" for underlying phenomena in source data (Xexéo, Morgado & Fiuza, 2009), can illuminate implicit or hidden relationships in unstructured data (Koutrika, Zadeh, and Garcia- Molina, 2009), and can aid in semantic exploration and comprehension of data by users (Bateman, Gutwin, & Nacenta, 2008).

In this study, two different types of Word Clouds were used, including "Concept Clouds" and "Word Networks" (see Figure 2). With respect to "Concept Clouds", three different types were used: Clouds that depicted the most frequent terms that the students were using in their

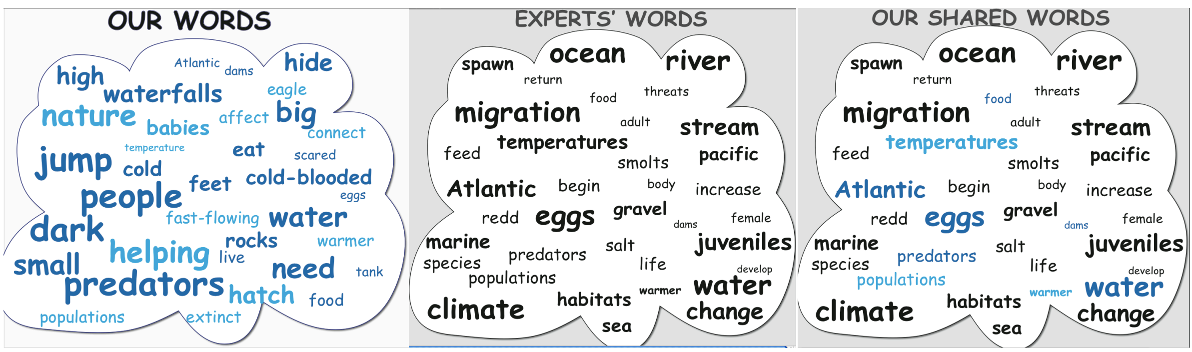

Figure 2. Concept Clouds including "Our Words", "Experts' Words" and "Our Shared Words"

naturally-occurring dialogue over time ("Our Words"); clouds that depicted key words that experts frequently used when talking about those same phenomena ("Expert Words"); and clouds that allowed students to assess the extent to which the words characterizing their discourse mapped onto those used in the expert dialogue, by means of colour-coding ("Our Shared Words"). These visualizations were geared to help students gain a sense of the semantic field of their discourse, and to enable the community to trace the use and longevity of new terms in their discourse over time. Furthermore, lack of common vocabulary between students and authoritative sources, as evidenced in the "Our Shared Words" cloud, could show limits of student understanding while also depicting terms that could help them to fruitfully expand their inquiry in new directions. Lastly, feedback that displayed the semantic connections students were making between important terms in their discourse would be displayed via Word Network visualizations (see Figure 3 on next page). These visualizations not only highlight the key words in a dialogue but make explicit the connections and relationships students are making between these words in their discourse.

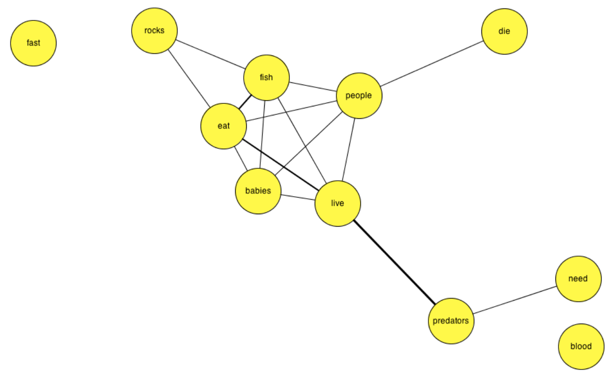

Figure 3. Word Network visualization produced by KBDeX

Research Questions

Embedding both meta-discourse and exposure to formative feedback within the regular Knowledge Building practices of a primary grade classroom provides an authentic context to test the extent of each support for building students' capacity to engage diversely and productively to dialogue oriented to knowledge creation. Accordingly, the main objectives for this study are as follows: to explore the extent to which new supports can help students expand their ways of contributing to collaborative explanation-seeking discourse, and to determine whether expanding contribution repertoires helps students to advance community knowledge as a whole by (a) engaging students in repeated meta-discourse discussions coupled with exposure to content-oriented feedback (b) engaging students in repeated meta-discourse sessions coupled with exposure to both content and contribution-oriented feedback.

METHOD

Participants

Participants for this study include 64 Grade 2 students (34 boys, 32 girls) from three consecutive Grade 2 classes that took place during the 2011, 2012 and 2013 school years. The 21 students from the Grade 2, 2011 class (10 boys, 11 girls) comprise the comparison group for this study, as they received no experimental treatments. The Grade 2, 2012 class (12 boys and 10 girls) were split up into two groups—Group A and Group B. The students in both of these groups comprise the first experimental cohort for this study. Each of these groups received slightly different treatments. The second experimental cohort consisted of 22 students (11 boys and 11 girls) from the Grade 2, 2013 class. All students in this class received the same set of treatments. Table 1 summarizes the different treatments each group received.

Table 1. Outline of treatments for the comparison and experimental groups.

Group	Pedagogical Treatment	Technological Treatment
2011 class (comparison)	No treatments	No treatments
2012 class – Group A (experimental)	Meta-discourse sessions	Concept Clouds
2012 class – Group B (experimental)	Meta-discourse sessions	Concept Clouds + New "Obtaining Information" Scaffold + MetaDiscourse Tool
2013 class (experimental)	Meta-discourse sessions	Concept Clouds + Word Networks + New "Our Improved Theory" + MetaDiscourse Tool

Classroom Context

All students across all three years completed a three-month Knowledge Building bird study and followed this up with another three-month inquiry on salmon. All classes examined similar artifacts, such as owl pellets, nests and feathers during their respective inquiries, and all classes participated in the "Lake Ontario Salmon Restoration Program" as part of their salmon study. The same teacher taught all three classes. The Grade 2s typically had one 45-minute session a week dedicated to Knowledge Building. In these sessions, the classes were split up into two groups in which half the students went to the library and the other half engaged in inquiry. Group A and B in the 2012 class correspond to these groups, which were chosen randomly by the teacher. An important component of the inquiries in all classes were "KB talks", which were whole-group discussions in which students posed questions, introduced ideas and examined artifacts as a group. These talks were generally followed up by 20 minutes of individual work on the Knowledge Forum database.

In the 2012 and 2013 experimental classes, regular "KB" talks included a series of meta-discourse sessions that were embedded throughout the inquiry. Students in these classes were also exposed to the various forms of feedback in the context of these reflective discussions. Integrating feedback visuals into meta-discourse sessions was designed to help position them as objects of public discourse that helped to make explicit important elements of the online dialogue as it emerged, and to serve as artifacts that the community could rally around during periods of reflection.

Dataset

The dataset for the study consists of student work as generated on three distinct Knowledge Forum databases and include the following: i) Grade 2, 2011—240 notes across four views, from both the bird study (111 notes, 3 views) and salmon units (129 notes, 1 view); ii) Grade 2, 2012—203 notes across eight views from the bird (175 notes, 7 views) and salmon units (90 notes, 1 view) units; i) Grade 2, 2013—259 notes across eight views from their bird (117 notes, 1 view) and salmon databases (143 notes, 1 view).

Plan of analysis

Data analysis focused on two main aspects, as described below:

i.) *Contribution Measures:* The "Ways of Contributing to Explanation-Seeking Discourse" coding guide was used to analyze all student notes, which includes 6 main categories and 24 subcategories (see Chuy, Resendes, Tarchi, et al., 2011). If a note exhibited more than one form of contribution, for example, "asking an explanatory question" and "proposing a theory", that note was coded as displaying two distinct contribution types. Two raters coded all databases. Agreement rates are as follows: 2011 class—97.85%; 2012 class—98.48%; 2013 class—99.34%.

ii.) *Knowledge Advancement:* Notes from the online discourse that were coded under the "theorizing" category were selected and subject to further analysis to assess community knowledge advancement, which was evaluated using scales for "scientificness" and "epistemic complexity" (Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007). Each scale has four levels that trace both increasing levels of scientific accuracy, as well as extent of explanatory elaboration as evident in student work. Overall, agreement rates for "scientificness" and "epistemic complexity" are as follows: 2011 class—94.95% and 89.94%; 2012 class—81.45% and 90.76%; 2013 class—89.13% and 84.77%, respectively.

Results

i.) *Did the experimental groups contribute more diversely than their peers in the comparison group?*

One-way ANOVA comparisons were conducted to test for differences in contribution repertories among the four groups. Significant differences were found for "theorizing", $F(3, 60) = 2.79$, $p < .05$, and "obtaining information", $F(3, 60) = 3.32$, $p < .05$. Post-hoc tests (TukeyHSD) show that Group B contributed significantly more than the 2013 class with respect to "theorizing" ($p < .05$, Cohens' $d = 2.86$). Differences were also found for a subcategory of "theorizing", namely "proposing an explanation", $F(3, 60) = 4.82$, $p < .01$. As post-hoc tests show, Group B outperformed the 2011 ($p < .05$, Cohen's $d = 1.89$) and 2013 class on this measure ($p < .01$, Cohen's $d = 2.32$). Similarly, Group B outperformed all other three groups on "obtaining information" ($p < .05$, Cohen's $d = 1.62$). More specifically, significant differences were found on the subcategory "introducing a new fact from a source" $F(3, 60) = 4.79$, $p < .01$, with post hoc tests revealing that Group B outdid the 2013 class on this measure ($p < .01$, Cohen's $d = 1.73$). Significant differences were also found for "reporting experimental results" $F(3, 60) = 3.69$, $p < .05$, with post hoc tests showing that both the 2013 class and Group B did better on this measure than the 2011 class ($p < .05$, Cohen's $d = 0.59$) (see Figure 6 on next page).

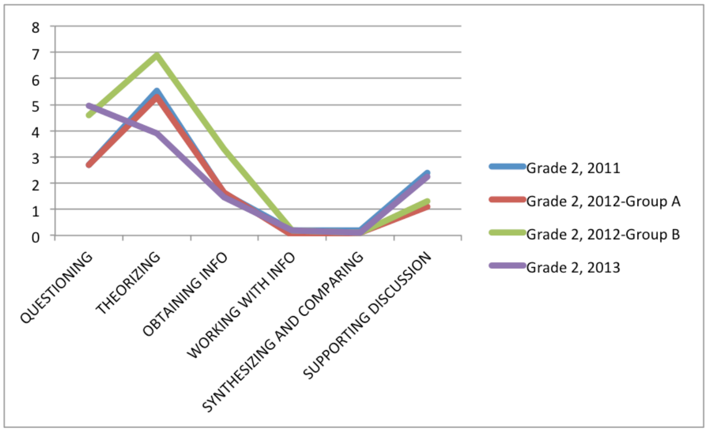

Figure 4. Contribution patterns for "Ways of Contributing" main categories

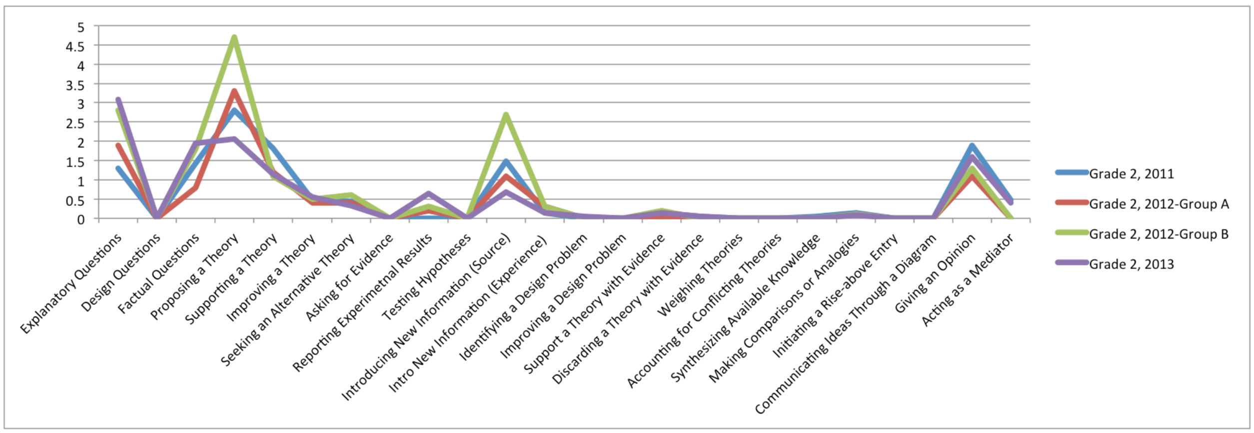

Figure 5. Contribution patterns for "Ways of Contributing" subcategories

These results indicate that students who were exposed to the pedagogical support along with both kinds of automated feedback—including both content (Word Clouds) and contribution-oriented (MetaDiscourse bar graph) visualizations—expanded their contribution repertoires in statistically significant ways. Among the two experimental groups who were exposed to both forms of automated feedback (Group B and the 2013 group), Group B stands out as showing the most gains. This group expanded their repertoires with respect to contribution types corresponding to "obtaining information" which was targeted, as well as "theorizing", which was unanticipated. Their performance could be explained in part by two factors: First, this group spent more time explicitly discussing the contribution category of "obtaining information" due to the introduction of the new scaffold, "This information is important because", in their database. This scaffold was present in the note interfaces in this year, was subsequently depicted on MetaDiscourse bar graphs, and was directly discussed in select group meta-discourse sessions. Thus, talking explicitly about scaffolds directly targeting "obtaining information" helped students to enhance their engagement in the targeted area. While the new scaffold "Our

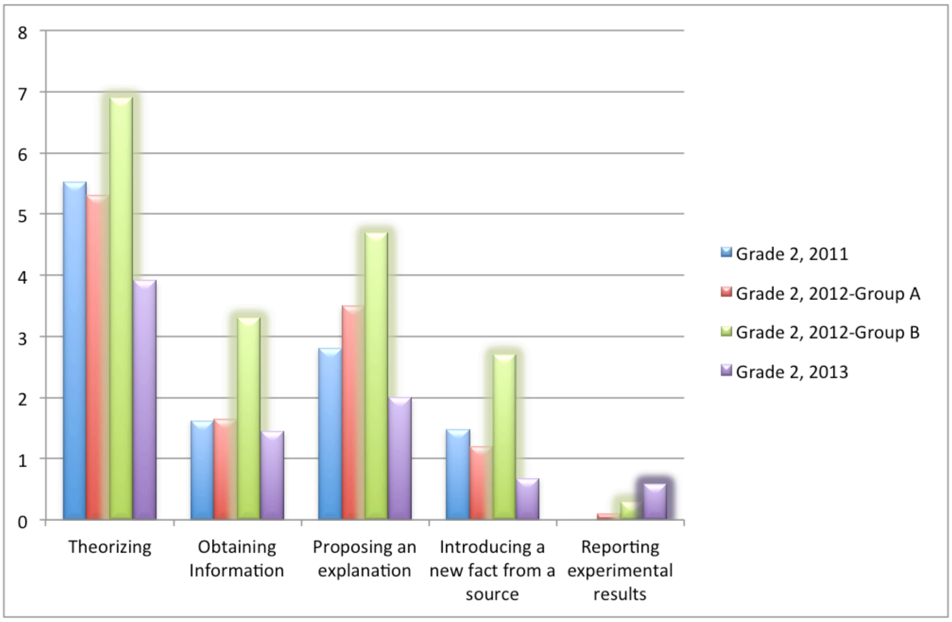

Figure 6. Significant differences between groups on "Ways of Contributing" categories

improved theory" was engaged in a similar manner during the inquiry work performed by the experimental group in 2013, the scaffold was used mainly to support collective contributions that emerged from group discussions, and as such these contributions were not included in analysis, which focused only on individually authored notes. Thus, the fact that the 2013 class did not show any significant gains in this contribution type may be more reflective of a weakness in the study design than any deficiency or failure in student work. However, that the 2013 class also demonstrated significant advancements with respect to the contribution type "reporting experimental results" indicates that students can still benefit and raise lower-level contribution types with the support of content and contribution-oriented feedback and without necessarily engaging in explicit discussion about any one particular way of contributing over another.

ii.) Did the experimental group achieve greater knowledge advancement?

One-way ANOVA comparisons were also conducted on knowledge advancement measures. Results showed a number of significant differences between groups on both "scientificness" $F(3, 57) = 8.51$, $p < .0001$ and "epistemic complexity" $F(3, 57) = 3.35$, ($p < .05$) (see Figure 7 on next page). Posthoc tests show that the 2011 class was outperformed by all three experimental groups ($p < .01$, Cohen's $d = 0.62$) for "scientificness" of explanations as well as "epistemic complexity" ($p < .05$, Cohen's $d = 0.46$). Among the experimental groups there were no significant differences. These findings suggest that conducting repeated meta-discourse sessions throughout an inquiry that include reflection on automated feedback that helps give students a "bird's eye view" of their own discourse can have a positive effect on primary aged students'

Knowledge Building work, and can help them write more scientifically accurate notes and articulate more elaborate scientific explanations.

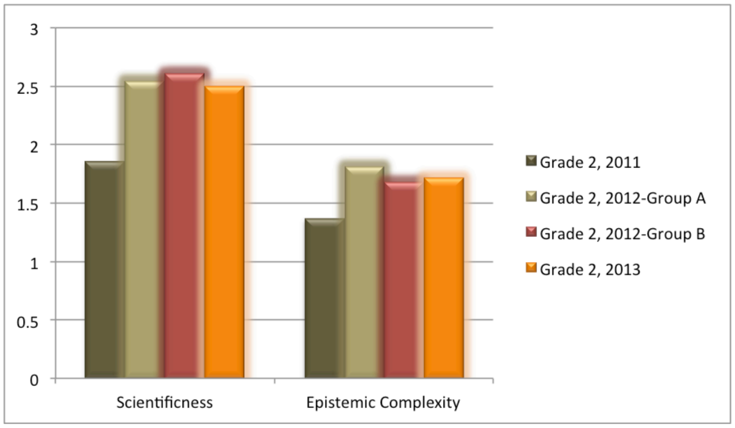

Figure 8. Knowledge advancement scores (*M*) across four groups

Discussion and Conclusions

In this study, we tested both pedagogical and technological supports designed to help students enhance their ways of contributing to explanation-seeking discourse. We focused on "meta-discourse sessions" as a pedagogical component and experimented with various forms of automated supports, including content (Word Clouds) and contribution-oriented (the Meta-Discourse bar graph) feedback. Meta-discourse allows students to discuss the progress and setbacks in their inquiry on the whole, while automated visualizations that present formative feedback to students about the ways they are participating help students gain a meta-perspective on the semantic and contribution makeup of their own dialogue. Four groups participated in this study, including one comparison group and three experimental groups, each of which were exposed to a different combination of supports.

Results of analysis showed that the MetaDiscourse bar graph in particular is productive for helping students to expand their contribution repertories, as the two experimental groups that were exposed to this feedback both showed significant gains in one or more targeted contribution types. Findings also show that focusing attention on particular contribution types can help trigger increased engagement with those ways of contributing to a significant degree, as the experimental group who utilized a new scaffold targeting "Obtaining information" boosted the presence of this contribution type as well as its corresponding subtypes more than any other group in the study. Furthermore, findings reveal that meta-discourse sessions that were facilitated by one or both kinds of feedback proved valuable for helping students to reflect on their ideas and to gain a broader perspective of their inquiry, and consequently to advance group knowledge to a greater degree than those students who did not participate in such sessions. Indeed, all three experimental groups who engaged in these reflective discussions showed significantly higher performance scores for knowledge advancement than the group that did not, regardless of the type of feedback visual they were exposed to. The positive effects of these forms of embedded assessments, both technological and pedagogical, was evident in all experimental groups, and support the assertion that these designs reflect examples of productive new assessments to support Knowledge Building work.

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