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Exploring Patterns in Student Dialogue While Using a Digital Platform Designed to Support Online Inquiry

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Online inquiry, or using the Internet to generate questions and then search for, analyse, and synthesise information about these questions, is an essential part of digital literacy. However, processes involved in online inquiry are substantially complex. Prior research suggests that digital platforms can scaffold online inquiry processes. Moreover, the value of scaffolding dialogue in collaborative activities has been shown to enhance critical thinking, an important part of online inquiry. This study investigates whether the use of digital platforms designed to scaffold online inquiry can support productive dialogue when used collaboratively.

Data from four pairs of high school students was collected as they worked together using both the digital platform and multiple online sources outside the platform to complete an online inquiry task. Each pair's interactions were analysed to investigate whether features of the digital platform prompted productive dialogue. In line with research suggesting the use of academic language influences content understanding, each pair's use of certain academic terms related to the task and digital platform's interface were also statistically examined. Results suggested that most productive dialogue occurred when using the digital platform. Additionally, two of the four academic terms investigated occurred more often in talk while interacting with the digital platform, compared to talk when on another website. A comparison of timelines associated with these terms offered examples of how initially they were said exclusively while on the tool, and then progressed towards independent use.

1. Introduction

Rapid advances in technology have resulted in the need for schools to cultivate a variety of skills to ensure students are able to excel in a changing world. The Internet has revolutionised the way that material is accessed, leading researchers to claim digital literacy as an essential 21st century competency (Voogt et al., 2013). One important element of this is online inquiry, i.e., using online resources to search for, analyse, and synthesise material to solve problems (Zhang and Quintana, 2012). The importance of digital literacy and online inquiry is not only recognised by academic literature, but also by national educational curricula (see Leu et al., 2011).

Nonetheless, finding and using information via the Internet has introduced new challenges compared to inquiry using books. The Internet is a continually changing entity, often lacking the quality assurance mechanisms associated with printed materials, such as encyclopaedias (Coiro and Dobler, 2007; Wegerif, 2015). It is therefore essential that students are equipped with the ability to critically evaluate information, as well as synthesise multiple sources to form a cohesive picture of different perspectives on a topic. Furthermore, the process of online inquiry itself is complex, consisting of various stages, from formulating a problem to communicating results to others (Leu et al., 2017).

Dialogue-oriented activities have been shown to be pedagogically effective for developing general reasoning skills (Wegerif, Mercer & Dawes, 1999), and reasoning skills related to online inquiry in particular (Knight and Mercer, 2015). However, productive dialogue is not guaranteed when students work collaboratively (Häkkinen and Mäkitalo-Siegl, 2007). Students often require support and scaffolding to deliberate and explore ideas effectively (Mercer et al., 2004).

Several digital platforms have been designed to *scaffold* students during online inquiry, such as by providing recommendations of web pages to visit (Lee, 2005) or using explicit prompts to elicit cognitive and metacognitive activities during online inquiry (Kiili, Coiro & Hämäläinen,

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2016; Zhang and Quintana, 2012). For example, a platform called IdeaKeeper provided separate workspaces for planning, searching, and analysing single websites, and for synthesising information from multiple websites (Zhang and Quintana, 2012). In each of these spaces, students' work was supported with guiding questions that directed their attention to important aspects of online inquiry, such as evaluating websites. The Online Inquiry Tool, the platform used in this study, provided one workspace that supported online inquiry processes similar to those in IdeaKeeper when students explored argumentative topics online (Kiili et al., 2016). Other studies have demonstrated that collaboration around digital platforms can support productive conversation (Major et al., 2018; Nussbaum et al., 2009).

However, there is a lack of understanding of how digital tools designed to support online inquiry foster productive conversation between students and joint reasoning at different phases of online inquiry (cf. Knight and Littleton, 2015). Additionally, the academic terms used to label various sections of a digital platform should prompt use of this language in a natural way, as pairs collaborate while using the features of the platform. The use of academic language has been shown to lead to the internalisation of the meaning behind those words (Moore and Schleppegrell, 2014; Vygotsky, 1986).

This study was designed to explore these ideas, guided by three questions:

1. What types of talk do pairs of students engage in during online inquiry with the support of a digital tool?
2. How do different phases of online inquiry and features of a digital tool stimulate productive dialogue?
3. Do features of the digital tool stimulate the use of academic language as pairs engage in online inquiry?

2. Theoretical Framework
2.1. Scaffolding
A key concept in the field of education is scaffolding. Scaffolding can be viewed as structured assistance that improves learners' performances; it allows for pedagogical flexibility, and should be temporary in nature (van Lier, 2004). One of the earliest discussions on scaffolding in educational research came from Wood, Bruner and Ross, (1976), who suggested six elements of scaffolding; these included recruiting interest, simplifying the task, maintaining task focus, marking critical features, controlling frustration, and demonstrating and modelling solutions to tasks.

Wertsch (1979) was one of the first to test empirically the viability of experienced others providing scaffolding through conversation, investigating adults who provided support for children solving problems at different developmental stages. In particular, Wertsch demonstrated how children's problem-solving skills started out as a scaffolded 'inter-psychological' process, and progressed to 'intra-psychological' internalised skills.

2.2. Dialogue and scaffolding
Dialogue serves several purposes during educational tasks: exchanging information and strategies, critiquing and building on ideas, enhancing explicit awareness of metacognitive strategies, and becoming aware that others have different experiences and views (Hicks, 1996; Mercer, 2013). Additionally, the ability to use specific academic terms related to a topic has been shown to mirror the understanding of the concepts underpinning the words (Lemke, 1990; Vygotsky, 1986). For example, the explanation of specific metalinguistic terms (e.g. noun phrase, simile) was shown to improve subsequent dialogue between pairs discussing language use (Schleppegrell, 2013). The educational activity provided an environment where the target language could be used several times naturally. This approach was shown to aid an individual's ability to use the target vocabulary unaided at a later date, implying better understanding of key concepts behind the terms (Moore and Schleppegrell, 2014).

Although, in theory, dialogue and conversation have multiple benefits, and can be forms of scaffolding, productive dialogue during educational tasks is not guaranteed (Häkkinen and Mäkitalo-Siegl, 2007). Mercer and colleagues have undertaken several studies to investigate potential scaffolding for dialogue in classrooms (e.g. Knight and Mercer, 2015; Mercer et al., 2004; Mercer and Sams, 2006; Wegerif et al., 1999). As part of their work, Mercer and colleagues created a typology of talk with three classifications: disputational, cumulative, and exploratory (Mercer and Sams, 2006). *Disputational talk* is classified as dialogue where partners are not collaborating. Short exchanges that lack any consideration of alternative hypotheses, or fail to provide any justification for viewpoints, are typical in this kind of interaction. Disputational talk is usually accompanied by partners making independent decisions about how to proceed, without looking for agreement. *Cumulative talk* consists of situations where pairs work together, creating an intersubjective understanding of a topic, but rarely engaging in any kind of critical assessment of information. *Exploratory talk* entails pairs actively engaged in assessment of ideas and data. Rather than merely pooling knowledge resources, exploratory talk is representative of a group deductive process. Qualitative descriptors that characterise exploratory talk include:

- Members sharing all relevant information;
- Inviting all group members to contribute to discussions;
- Opinions and ideas being respected and deliberated;
- Clear reasons for perspectives being requested;
- Challenges and alternatives being made explicit and negotiated;
- Group consensus being reached before decisions or actions are made (Mercer et al., 2004).

As discussed by Felton, Garcia-Mila and Gilabert (2009), another qualitative consideration when distinguishing between the types of talk is the intention behind utterances. Disputational talk has the goal of persuading others to adopt your perspective, whereas exploratory

talk has the objective of discovering a viewpoint. Cumulative talk, although not discussed explicitly by Felton and colleagues, could be considered as having the aim of accumulating knowledge and views.

Digital platforms have been found to have the capability of enhancing student dialogue. Nussbaum et al., (2009) found that by forcing participants to reach a consensus with software, students more deeply engaged in dialogue. Mercer et al., (2007) proposed that software can be used to prompt quality dialogue, if the ecological conditions are correct. For example, features of software could be considered conditions that prompt and focus dialogue.

2.3. Dialogue and online inquiry

Online inquiry is one context in which the benefits of scaffolded dialogue have been examined (e.g. Kiili, 2013; Knight and Mercer, 2015). Online inquiry is a collection of processes that result in finding material to answer a question using online resources (Zhang and Quintana, 2012). Leu and his colleagues have proposed that online research and comprehension comprises five cyclical phases: 1) ascertaining a problem, 2) discovering relevant information, 3) evaluating that information, 4) synthesising information from multiple sources, and 5) communicating findings to others (Leu et al., 2011, 2017).

As noted by Wegerif (2015), using the Internet is similar to finding information from print sources, but differs in several important ways. The Internet is not a stable and unchangeable object in the same way that a book is; it offers the opportunity for those using it to engage in dialogue, contributing to the knowledge available for others (e.g. Wikipedia). As a source of information, the Internet removes many limitations of print sources, but it requires additional strategies to find reliable and relevant material. For example, a study examining the strategies used by competent 11 to 12 years old readers found that online inquiry required prior knowledge of web page structures,

as well as forward inferential reasoning, to navigate websites efficiently (Coiro and Dobler, 2007).

Research on scaffolding online inquiry has suggested that dialogue between pairs can aid students in completing their tasks. In a study on collaborative online inquiry in students aged between 8 and 11 years old in the USA, Sekeres et al., (2014) found although the quality and nature of conversations varied from pair to pair, students could use conversation to build on each other's ideas. Knight and Mercer's (2015) study similarly found that the quality of discussions engaged in, as indicated by the amount of exploratory talk between students, was important for successfully completing online inquiry tasks.

Digital platforms have also been investigated for their ability to scaffold online inquiry. Quintana, Zhang and Krajcik (2005) found that software could scaffold metacognitive processes involved in online inquiry by explicitly providing prompts and tools for users to consider certain learning strategies. Kiili (2013) found that the use of an argument graph tool to support online inquiry also assisted the metacognitive skills needed for successful collaborative online reading. Although these tools have been demonstrated to scaffold online inquiry, how they foster dialogue during this process when used by pairs has yet to be assessed.

3. Methods
3.1. Digital platform

In this study, students' online inquiry focusing on a controversial issue was supported with the Online Inquiry Tool (see **Figure 1**), a digital platform designed to scaffold challenging aspects of online inquiry (Kiili et al., 2016). To aid students' abilities to construct a multifaceted understanding of the issue, tool use began with a prompt for readers to generate a claim that helped to explore the issue from different perspectives. At the top of the tool's interface, there was also an affordance labelled 'Palette of Perspectives'. When
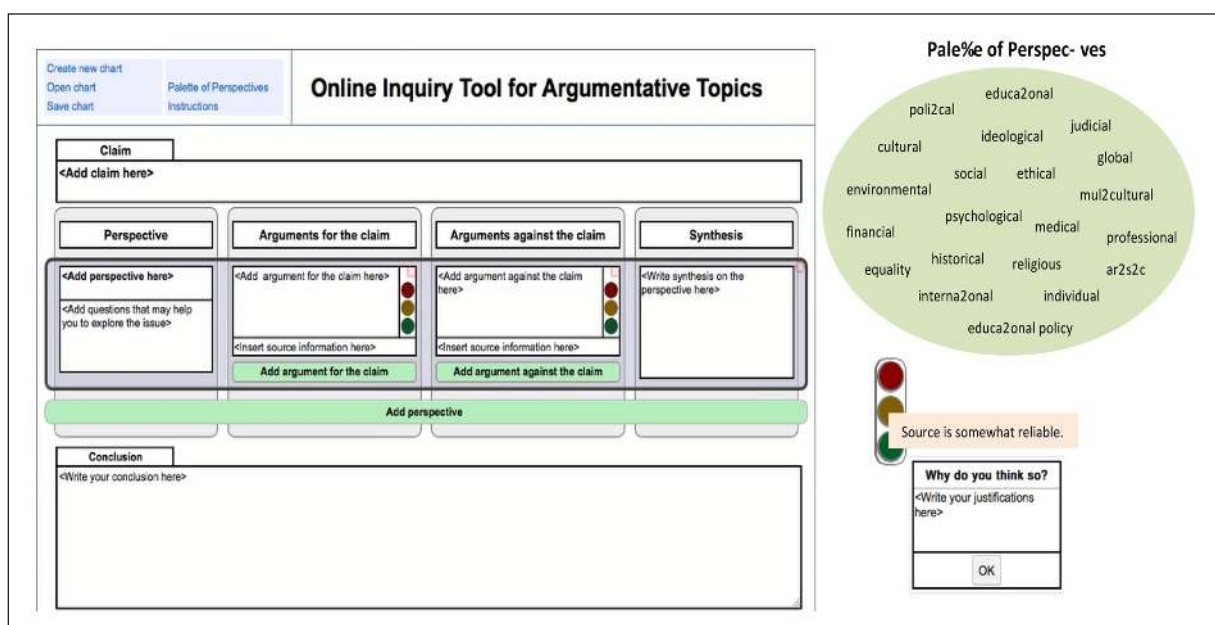
Figure 1: Screenshots of the Online Inquiry Tool and the affordances for planning with perspectives and evaluation of sources.

clicked, this opened a diagram showcasing different potential perspectives that students could consider when tackling how to build a balanced representation of their claim.

Furthermore, the tool prompted students to search for arguments for and against the claim from each perspective, and record the source from which they found the argument. Additional tool features were designed to support critical evaluation of sources. For each source, a traffic light rating system prompted students to rate its quality as reliable, somewhat reliable, or not at all reliable. After indicating the traffic light colour, a box appeared to prompt students to enter the reason for their rating. Finally, the tool provided a box for synthesising arguments with consideration of each perspective. The final product produced after entering notes into the tool during online inquiry was called an argument graph.

3.2. Participants

Participants ($n = 8$; 4 pairs) for this study were a subset of a larger teaching experiment, where students across multiple classrooms in the USA and Finland completed similar tasks either individually or in pairs. The larger experiment was designed to investigate the potential of the Online Inquiry Tool to support searching for, evaluating, and synthesising arguments after reading across multiple sources. In one pair, both students were female (Dyad 1), whereas three of the pairs consisted of a male student paired with a female student (Dyads 2–4). All students were either 16 or 17 years old.

These four pairs of students were selected from a larger class of 14 based in one high school Honors programme in northeastern USA. Honors classes involve higher-level coursework that proceeds at a faster pace and covers more material than regular classes. Data from the other six students in this class were not included in the current analysis, because they worked independently on the task as part of the larger experiment's design.

3.3. Task

Students were asked to conduct online inquiry and write an argumentative essay on either the use of social media increasing the quality of life, or on allowing the genetic modification of organisms. All pairs included in this study happened to choose the social media topic. Before engaging in the task, students received a 35-minute lesson on argumentation and how to use the Online Inquiry Tool.

The students then proceeded to have two sessions on two different days (approximately 30 and 35 minutes, respectively), in which they used the Internet to find information to include in their argumentative essay, supported by the use of the Online Inquiry Tool. All pairs conducted the task at the same time and were seated far enough away from others that their conversations could not be easily overheard. The final step was a 60-minute session in which all students in the class were asked to compose their argumentative essays individually (regardless of whether they worked individually or with a partner to conduct their online research).

3.4. Data collection

Data sources for this study consisted of audio and screen recordings. Recordings were made using QuickTime Player's Screen Recording function to capture both activity on screen and the audio of each pair. After the recording phase of data collection was complete, the audio for each pair was transcribed.

3.5. Data analysis

3.5.1. Product data

Students' argument graphs were scored using a six-point rubric we developed with four criteria that included 1) planning with perspectives, 2) argumentation, 3) source evaluation, and 4) synthesis. Each of the four elements was assigned a score ranging from 0 to 5 points, for a total of 20 possible points for a high-quality argument graph (see Appendix). **Table 1** shows the quality scores given to pairs' graphs, and how they were ranked among the graphs produced by the whole class (ten graphs in total).

3.5.2. Process data

Process data was analysed in four phases, as shown in **Figure 2**.

Phase 1: Identifying and coding episodes for online inquiry phases

In Phase 1, each pair's transcript of dialogue was divided into episodes, defined as a series of exchanges between partners focusing on a particular process of online inquiry. Episodic analysis has previously been used in research into

Table 1: Score indicating the quality of graph produced and relative class ranking.

Pair	Score indicating the quality of graph*	Rank in class
1	17	2nd
2	17	2nd
3	14	5th
4	5	10th

* Maximum score of graph quality was 20.
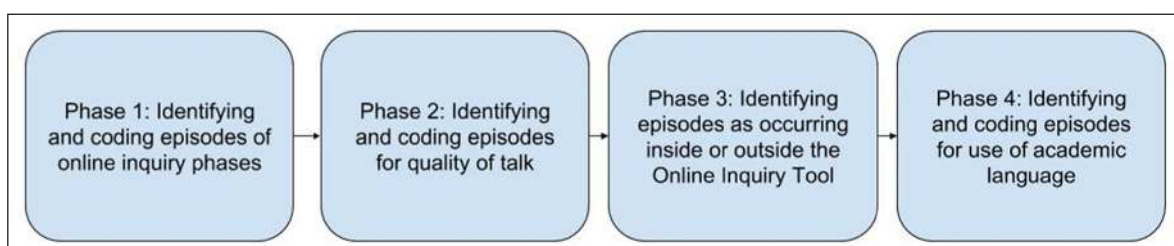
Figure 2: Phases of analysis.

collaborative interactions (e.g. Kiili et al., 2012; Mercer and Sams, 2006). Conversation is fluid and highly influenced by context; it is therefore more meaningful to look at episodes of dialogue, rather than coding each individual sentence spoken.

Next, each episode was coded in line with the online inquiry processes suggested by Leu et al., (2011, 2017), including identifying a problem, searching for information, evaluating, synthesising, and communicating. Then, we inductively (Strauss and Corbin, 1988) expanded the coding scheme to account for dialogue that represented two additional processes: "regulating the activity" and "off-task processes". A detailed summary of the types of activity that fit into each category is given in **Table 2**.

Although seven distinct categories were identified, there was sometimes an overlap of processes. For example, a single line of dialogue representing evaluation of a website's potential reliability was often spoken during the search process. In areas where there was overlap, the dialogue was identified as whichever inquiry process was most prominent in the conversation as a whole. The length of each episode was measured in seconds and totals were calculated for each process. Two independent researchers coded 25% of the online inquiry episodes reaching a Kappa value (Cohen, 1960) of 0.74. Disagreements were resolved through discussion.

Phase 2: Identifying and coding episodes for quality of talk
In Phase 2, another layer of episodes was identified in the transcripts to indicate the quality of talk occuring as pairs engaged in the online inquiry task. This step followed conventions of sociocultural discourse analysis as outlined by Mercer (2004, 2010). New episodes were created to align with variations in talk quality and then labelled as disputational, cumulative or exploratory talk. *Disputational talk* was defined as non-collaborative interactions, *cumulative talk* consisted of non-critical accumulation of knowledge, and *exploratory talk* involved thoughtful assessment of opinions. Although the start and finish of episodes related

to talk quality sometimes coincided with the online inquiry episodes identified in Phase 1, alignment was not forced.

Long periods of off-task conversation were coded as either cumulative or disputational. In accordance with the features of off-task talk (see Lemke, 1990), certain kinds of off-task talk can serve the purpose of creating a beneficial relationship between partners, aiding in knowledge-building. Although this kind of talk does not involve deeply engaging with subject matter (a feature of exploratory talk), sometimes, in our data, this talk did further the progress of an activity. Thus, we coded these instances of off-task talk as cumulative. However, there were also episodes of off-task talk that more closely resembled disputational talk, due to the confrontational nature of the exchanges. These kinds of off-task talk were correspondingly categorised as disputational.

In addition to identifying and coding data at the episodic level, sociocultural discourse analysis is often accompanied by a quantitative count of certain words that have been observed to occur frequently during exploratory talk (e.g. Knight and Mercer, 2015). Mercer (2004) highlighted the words 'because', 'agree', and 'I think' as indicative of exploratory talk. Accordingly, an additional dimension of coding in this phase involved counting the frequency of these three words in our data. However, as with Knight and Mercer's (2015) study, context was taken into account, causing some uses of these words to be discounted from the final totals. Two independent researchers coded 25% of the episodes of talk reaching a Kappa value of 0.86. Disagreements were resolved through discussion.

Phase 3: Identifying episodes as occurring inside or outside the Online Inquiry Tool
To better understand the nature of talk stimulated by the Online Inquiry Tool during different online inquiry processes, the total amount of time students spent inside the tool interface and outside the tool interface (e.g. using a search engine, reading websites) was calculated by labelling the location of each episode of online inquiry or dialogue. Each episode's location was judged

Table 2: Processes applied to dialogic episodes of online inquiry.

Process	Focus of dialogue
Identifying a problem	Discussions around a given problem, such as identifying potential perspectives and questions.
Searching for information	Discussions around formulation of queries for search engines and selection of relevant information sources.
Evaluating	Discussions around the reliability of sources, such as author's expertise and quality of information.
Synthesising	Discussions around combining information from multiple sources and balanced interpretations of a perspective.
Communicating	Discussions around use of located information when writing a summary.
Regulating the activity	Discussions around completition of the task not related to any particular online inquiry phase, such as planning or evaluating activities.
Off-task processes	Any conversation not related to completion of the task (e.g. discussing free time activities).

by the amount of time that students spent looking at the Online Inquiry Tool, as opposed to another web page, for the duration of the episode. If most time in that episode was spent inside the tool, then it was labelled as 'on tool'. Otherwise, it was labelled as 'off tool'.

Phase 4: Identifying and coding episodes for use of academic language

To understand whether the Online Inquiry Tool played a role in the acquisition of academic language, students' use of four keywords was investigated: claim, argument, perspective and synthesis. These words were selected as they were explicit labels for sections of the tool, as well as words that are not necessarily used in everyday conversation. During the introductory session, before using the Online Inquiry Tool to search for information, students received explanations as to the meaning of these words, so they should have had at least a basic understanding of the concepts they represent. Although students used alternative phrases and paraphrased these words several times, attention was only paid specifically to these words as the ones with a direct link to the Online Inquiry Tool. To assess if the tool could be stimulating the use of these academic terms, the amount of times each word was spoken was recorded, along with whether a student was on the tool or on another website at the time of use.

To assess if there was sufficient evidence to claim a significant difference between term use on the tool versus other websites, a Fisher's exact test was carried out for each academic term.

4. Results

4.1. Types of talk during online inquiry

Table 3 shows the types of talk engaged in during online inquiry by the different partnerships. The amount of exploratory talk engaged in by Dyads 1, 2, and 3 was relatively similar. Only Dyad 4 demonstrated a notable difference in the amount of exploratory talk engaged in, displaying approximately five times less than the other pairs. All pairs spent most of their time engaged in cumulative talk (ranging from 74.5% to 86.1%), as can be noted by the high percentages across the partnerships, as well as the long length of the average cumulative episode.

Table 4 provides the quantitative counts of the relative frequency of words associated with exploratory talk. Dyad 3 demonstrated high occurrences of these words, particularly of 'I think'. Dyad 2's total count is surprisingly low, considering that episodic analysis showed that the pair engaged in similar amounts of exploratory talk to Dyads 1 and 3. Although this could be for several reasons, it should be noted that Dyad 2 also engaged in far more periods of silence than the other pairs. The total word count of the transcript for Dyad 2 (2650 words) was much lower than either Dyad 1 (4839 words) or 3 (4686 words), which could explain the relatively lower number of occurrences.

4.2. Exploratory talk stimulated by online inquiry phases and tool use

Figure 3, illustrating the proportion of time spent in exploratory talk by online inquiry phase, shows that evaluation of sources in particular stimulated exploratory talk.

Among three of the pairs (Dyads 1–3), exploratory talk also occurred during the 'identifying a problem' phase of online inquiry. Notably, searching for information and synthesising information did not stimulate much exploratory talk. Only Dyad 2 engaged in exploratory talk during synthesising.

Figure 3 additionally shows the proportion of exploratory talk in each phase of online inquiry that took place while using the Online Inquiry Tool. Exploratory talk in the evaluation phases took place largely while using the Online Inquiry Tool for Dyads 1, 2, and 4. Similarly Dyads 1, 2, and 3 engaged in exploratory talk when identifying problems primarily, or exclusively in the case of Dyad 2, when using the Online Inquiry Tool. These findings suggest that the tool may have stimulated exploratory talk in each pair, at least in some phases of online inquiry.

From examination of the video context in which the large amounts of exploratory talk took place, several occasions of the features of the Online Inquiry Tool prompting exploratory talk could be observed. **Transcript 1** provides an example of such an exchange.

Transcript 2 provides another example of how the features of the digital platform supported exploratory talk

Transcript 1: Example of talk on identifying the problem prompted by interaction with the Online Inquiry Tool in Dyad 2.

Bruce:	Let's go about this in a different way. (clicks on perspective box, in which 'medical' is currently input) So medical. Let's put it as….
Jennifer:	Let's just do a section of it.
Bruce:	Teenagers, let's try that. Or no, let's try hmmmm. Let's go back to medical.
Jennifer:	Let's just do like, a small, we're thinking about a big picture. Instead of looking at the big picture just take a slice of it.
Bruce:	Yeah, let's do that. So how, you know, social media has caused, let's just, and it's caused suicides, depression, kids who leave school, whatever. So (reading as typing) how it's caused….
Jennifer:	Mental diseases.

Transcript 2: Example of talk on evaluation prompted by interaction with the Online Inquiry Tool in Dyad 3.

Anna-Marie:	Do you think it's green or yellow?
Pietro:	Yellow. Yeah, yellow.
Anna-Marie:	(clicking various quality ratings) It just makes them all light up when you click it. (completes the 'Why do you think so?' box by copying "Author of website may have a bias" from a previous source)
Pietro:	Also, I think it could be slightly out of date because this is from, let's see when it was published.
Anna-Marie:	(Navigates to source) They don't have a date.
Pietro:	I saw the sources were from, right go a little down, 2009, 2010.

Table 3: Proportion of time engaged in exploratory, cumulative and disputational talk.

	Dyad 1			Dyad 2			Dyad 3			Dyad 4		
	Exploratory	Cumulative	Disputational	Exploratory	Cumulative	Disputational	Exploratory	Cumulative	Disputational	Exploratory	Cumulative	Disputational
Percentage of total time in talk type	16.4%	74.5%	9.2%	13.9%	86.1%	0.0%	15.5%	84.5%	0.0%	3.0%	74.8%	22.2%
Average episode length (s)	70.6	262.3	71.0	75.6	468.1	0.0	54.6	251.9	0.0	28.3	157.2	55.9
Total number of episodes	9	11	5	7	7	0	11	13	0	4	18	15

between a pair. In this case the explicit need to evaluate the reliability of the source prompted one student to expand on the initial explanation inserted into the tool by her partner.

4.3. Acquisition of academic language supported through use of tool

As presented in **Table 5**, the pattern of use of the four highlighted academic terms associated with argumentation varied across dyads. Both the terms 'argument' and 'claim' were mentioned significantly more while using the Online Inquiry Tool than would have been expected if the tool had no effect.

Dyad 2 appeared to underuse terms in comparison to their understanding of the concepts, as demonstrated by the assessment of their completed argument graph. However, as discussed above, this could be due to the pair

Table 4: Frequency count of words associated with exploratory talk for each pair.

	Dyad 1	Dyad 2	Dyad 3	Dyad 4
Because/cuz	13	7	19	6
Agree	0	0	1	0
I think	10	11	25	14
Total	23	18	45	20

producing approximately half the total word count during the exercise compared to other dyads. Dyad 1 more frequently used the academic terms while away from the tool than other dyads. Given the high rating of their argument graph, this could be due to them beginning to internalise the concepts behind the academic language.

Further information on use of academic language can be garnered from examining timelines of when pairs were on the tool, and when target academic terms were spoken. **Figure 4** shows when Dyad 1 was on and off the Online Inquiry Tool, as well as when each of the academic terms of interest were said.

Dyad 1's timeline showed that the pair was capable of using 'perspective' independently throughout the exercise, meaning that they did not require scaffolding for this term. However, the terms 'argument' and 'claim' were used almost exclusively on the tool initially. On the second day of the task this changes, as both terms are said multiple times while on other websites, suggesting acclimatisation to the words. Other pairs displayed similar patterns.

5. Discussion

The purpose of this exploratory study was to investigate the patterns of dialogue students engage in while using a digital platform designed to support online inquiry. The study showed that the four examined pairs engaged most often in cumulative talk during online inquiry. The three dyads that engaged in the largest amount of exploratory
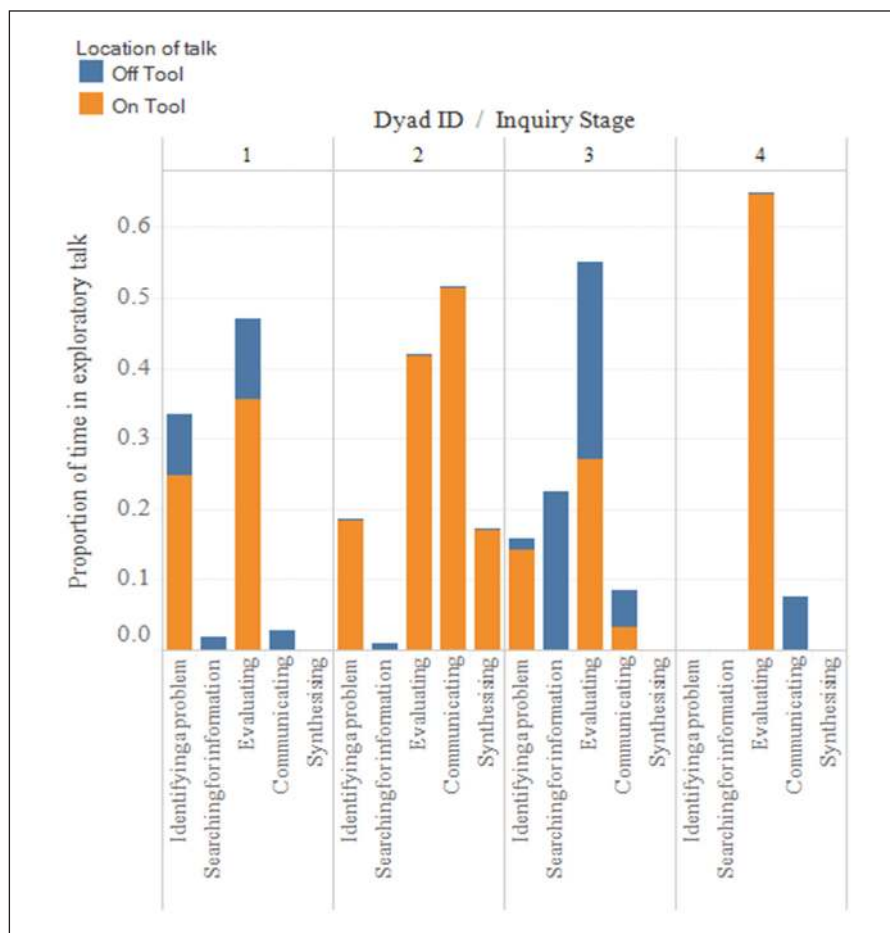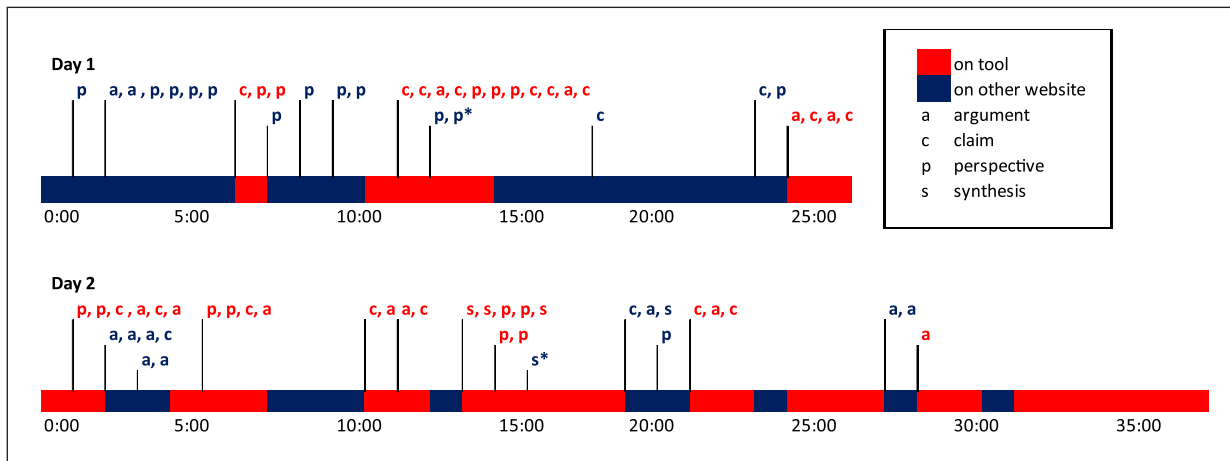

Figure 3: Proportion of time spent in exploratory talk by online inquiry phase and on tool and off tool.

Table 5: Frequency and location of utterance of selected academic terms associated with argumentation during online inquiry.

Academic term	Dyad 1			Dyad 2			Dyad 3			Dyad 4		
	Frequency	Occurrence on tool	Occurrence off tool	Frequency	Occurrence on tool	Occurrence off tool	Frequency	Occurrence on tool	Occurrence off tool	Frequency	Occurrence on tool	Occurrence off tool
Perspective	26	50.0%	50.0%	12	75.0%	25.0%	14	42.9%	57.1%	2	100.0%	0.0%
Argument***	21	52.4%	47.6%	14	100.0%	0.0%	8	100.0%	0.0%	13	92.3%	7.7%
Claim*	20	80.0%	20.0%	12	83.3%	16.7%	8	87.5%	12.5%	5	100.0%	0.0%
Synthesis	5	60.0%	40.0%	2	100.0%	0.0%	3	100.0%	0.0%	3	66.7%	33.3%
Total	72	59.7%	40.3%	40	87.5%	12.5%	33	72.7%	27.3%	23	91.3%	8.7%

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Figure 4: Timeline of Dyad 1 patterns of academic language use on and off the Online Inquiry Tool.
*Timelines displays periods that lasted longer than 30 seconds. Twice Dyad 1 navigated away from the tool for less than 30 seconds and used keywords.

talk (14–16%) received considerably higher scores on the quality of their graphs than the dyad that engaged in relatively little exploratory talk. This is in line with previous findings where exploratory talk has been empirically demonstrated to be associated with reasoning ability (Mercer et al., 2004). Furthermore, these findings support prior work that suggests that, even among high achieving students such as those in this Honors programme, productive collaboration and exploratory talk may require scaffolding (Häkkinen & Mäkitalo-Siegl, 2007; Mercer and Sams, 2006). The results also provide another example of how the amount of exploratory talk engaged in corresponds to achievement of groups in general, as observed by Knight and Mercer (2015).

Methodologically, this study illustrates the importance of complementing quantitative analysis with qualitative data to examine quality of talk, as purported by Mercer (2004, 2010). With Dyad 3, for example, qualitative episodic analysis was necessary to provide a contrast to the quantitative count of words associated with exploratory talk. Even though Dyad 3 spoke almost double the number of words associated with exploratory talk compared to any other dyad, episodic analyses showed they actually engaged in amounts of exploratory talk similar to Dyads 1 and 2.

This study suggests the Online Inquiry Tool may be a promising platform to scaffold productive dialogue during online inquiry. All dyads, except one, undertook most of their exploratory talk while using the Online Inquiry Tool. For Dyads 1 and 2, having most of their exploratory talk on the Online Inquiry Tool appeared to allow them to create a better quality artefact, i.e. their final graph, that they could use for later activities. Mercer et al., (2007) proposed that, when using digital platforms to support collaborative learning, it is important that software features provide opportunities to have productive discussions. Qualitative exploration of the transcript and video provided examples, where features of the digital tool prompted productive dialogue.

It should also be noted that features of the Online Inquiry Tool seemed to scaffold certain phases of online inquiry more successfully than others. Dyads 1, 2, and 4

engaged in most of their exploratory talk around evaluating sources while using the tool. The reason for this finding might be that the traffic light rating affordance, with a requirement for justification, explicitly prompted students' reasoning. In our previous study (Kiili, Coiro & Räikkönen, in press), we found that when completing online research with the Online Inquiry Tool, paired students, in certain conditions, evaluated online sources more actively, diversely and with higher quality compared to students who worked individually. One reason for this finding, as suggested by the present study, could be the productive dialogue stimulated by the tool.

Identifying a problem seemed to be another online inquiry process that the tool supported. Dyads 1, 2, and 3 spent a considerable amount of their exploratory talk around this process. From observation of tool use, students were encouraged to identify specific perspectives to inform their online inquiry, stimulating productive discussions when identifying problems. This is an encouraging observation because students often start their online research without any planning, resulting in ineffective search behaviour (cf. Quintana et al., 2005).

However, sections of the Online Inquiry Tool designed to promote synthesising, i.e., supporting arguments and counter-arguments within each perspective, did not seem to prompt quality talk in any pairs except Dyad 2. This is possibly due to tool affordances that did not break the synthesis process into smaller steps, unlike the affordances for evaluating and identifying problems. Synthesising information is also one of the most complex processes in online inquiry.

From the perspective of stimulating the use of academic language, the Online Inquiry Tool introduced four academic terms associated with text-based argumentation with multiple sources (claim, argument, perspective and synthesis). Both the academic terms 'argument' and 'claim' were used significantly more while on the Online Inquiry Tool compared to other websites. The timelines analysed for each pair suggested a pattern that, with the exception of the word 'perspective' for Dyad 1, each academic term was used predominantly on the tool at least initially. For example, **Figure 4** shows how Dyad 1 initially started

using the term 'claim' exclusively on the Online Inquiry Tool, and then progressed to using it independently when exploring websites.

'Synthesis', on the other hand, was used infrequently by all pairs and, interestingly, its meaning was a subject of discussion. This was perhaps most aptly demonstrated by two pairs performing a Google search to find a definition of synthesising. As the pairs used the academic term infrequently, they may have required more explanation and understanding of the concept prior to the activity before they could use the term. Limited understanding of the meaning of synthesis may also explain why there was relatively limited exploratory talk from the pairs during synthesising. More features to break down the synthesising process, or at least define it, would be improvements in future iterations of the digital platform. In future work, it would be beneficial to evaluate students' understanding of each of the terms before and after the activity, similar to approaches used by Moore and Schleppegrell (2014). This would further establish a connection between use of academic language and understanding of the concepts behind the words.

To summarise, even though the Online Inquiry Tool was designed to scaffold online inquiry, this study presents evidence that it is also capable of supporting productive dialogue when used collaboratively. This study builds on prior research (Nussbaum et al., 2009) that found prompts and features of digital platforms can help students engage in productive dialogue, by suggesting that talk may be enhanced even when neither software nor activity are specifically designed to scaffold productive dialogue.

In addition, this study highlights the possibility that collaborative use of digital platforms scaffold acquisition of academic language. Even though the number of utterances in this study were relatively few, two of the four academic terms were used significantly more during use of the digital platform. Future research should investigate not only this on a larger scale, but also how dialogue prompted by the digital platform compares to other forms of scaffolding. Providing guidelines on how to collaborate productively could also be beneficial for teachers and students.

6. Limitations
This study has several limitations. First, consisting of in-depth analysis of only four pairs, it was small-scale and descriptive in nature. It would be beneficial to conduct a larger-scale study aimed at creating a more comprehensive understanding of how to use the tool productively. However, the methods used in this study were labour intensive, which would limit the scalability of replica studies using a similar design. Further studies could potentially overcome this limitation by using automated data collection methods to facilitate the analysis of a larger number of pairs in a diversity of settings. For example, the digital platform could be modified to collect click data, or automatic speech recognition software could be used to automatically detect usage of academic terms. Additionally, sociometric badges could be used to record information on turn taking in dialogue and body positioning (Parker et al., 2018). This approach would be especially beneficial

as the relationship of the students involved is likely to play a role in the pair dynamics, but standard methods of analysing social interactions can be labour intensive.

Second, the study was undertaken with high achieving students, limiting our interpretations to a specific population. As a form of scaffolding, the tool could be especially useful for lower achieving students, and this would be a fruitful direction for future research. Third, the measure of success was an argumentative graph produced by students and we did not evaluate students' final products, the essays written individually on the basis of joint graphs. In spite of these limitations, this study provided a multifaceted picture of how four pairs used a digital platform to support their productive dialogue.

Additional File
The additional file for this article can be found as follows:

- **Appendix.** Scoring rubric for evaluating the quality of argument graphs. DOI: https://doi.org/10.5334/jime.518.s1

Author Contributions
Victoria Louise Murphy conducted the data analysis. Julie Coiro and Carita Kiili were responsible for the research design and data collection of the larger project from which the data came. All authors contributed to the creation of this manuscript.

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