VARIATION OF STUDENT ENGAGEMENT BETWEEN DIFFERENT ALGEBRA TASKS

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In this study, we analyse how 7th grade students' engagement during small group work differed in two consecutive algebra lessons: in the first lesson students solved equations and in the second lesson they created equations for other small groups to solve. Data was collected by videorecording the work of two groups in both lessons. Through directed content analysis, categories indicating student engagement were formed based on previous research and refined during analysis. The analysis revealed a change from individual engagement to collaborative engagement between lessons and an increase in many passive students' engagement. Task characteristics which may affect the type and amount of engagement are discussed.

INTRODUCTION

Transition from arithmetic to algebra is a difficult point in school mathematics (e.g. Kieran, 1992) often resulting in a decline in student engagement. Therefore, it is important to find ways to engage students when transitioning to algebra. Nyman and Kilhamn (2015) found that a group of Swedish teachers tried to engage students in algebra mostly through contextual or organisational methods. They concluded that it is important to find ways to engage through the content itself and to study which characteristics of algebra tasks are related to engagement.

Open problems have been reported to be potentially engaging tasks (e.g. Sullivan, Mousley, & Zevenbergen, 2006). In this study, we are comparing a typical equation solving lesson and a lesson in which students create equations. The latter open problem solving activity is called Reversed Equation Solving. The research question is what kind of differences in cognitive engagement and peer-to-peer interaction emerge between these lessons for two small groups. We also discuss how characteristics of the tasks may relate to differences in engagement and interaction.

ENGAGEMENT

The quality or level of engagement has generally been found to have a profound effect on learning outcomes (see review by Fredricks, Blumenfeld, & Paris, 2004). Engagement is a hot topic in the scientific discussion which shows from a broad range of recent studies related to engagement: questionnaire development and defining the construct of engagement and it's dimensions (see overview of a recent special issue by Fredricks, Filsecker, & Lawson, 2016), teachers' and students' views of engagement

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(Nyman & Kilhamn, 2015), general factors related to continuation and decline of engagement (Henningsen & Stein, 1997).

Shortly, engagement can be defined as the extent to which a student is actively involved with the content of a learning activity (Helme & Clarke, 2001). A common conceptualization is that engagement comprises three distinct, but interrelated dimensions: behavioral, emotional and cognitive engagement (Fredricks et al. 2004). In this paper, we mostly concentrate on cognitive engagement although observation of peer-to-peer interaction is also related to the behavioral dimension. Fredricks et al. (2004) define cognitive engagement as student's level of investment in learning. According to them, it includes being thoughtful, strategic, and willing to exert the necessary effort to learn and overcome challenges.

Engagement is often analysed from questionnaire or self-report data. Several studies have concluded that an important next step would be to study engagement by observing students over a sequence of lessons (Fredricks et al., 2004; Helme & Clarke, 2001). We are trying to tackle that challenge by developing further methods to capture indicators of cognitive engagement through video-study.

Fredricks, Wang, et al. (2016) studied indicators of cognitive engagement described by students and teachers in interviews. They reported thinking hard, connecting ideas, trying to understand ideas, persisting and self-monitoring as indicators of cognitive engagement. Helme and Clarke (2001) studied engagement from mathematics lesson videos. They used a framework where indicators of cognitive engagement specific to mathematics include questioning, completing peer utterances, exchanging ideas, giving explanations, justifying and gestures. The indicators of engagement used by Helme and Clarke (2001) have similarities with categories used in studying student interaction. For example, Asterhan and Schwarz (2009) used categories for dialogical moves which overlap with the categories by Helme and Clarke. Also differences exist as Asterhan and Schawrz's categorisation is more detailed and includes, for example, challenging as a separate category. Nevertheless, when students participate in collaborative activities, visible indicators of cognitive engagement are related to students' interactional moves.

METHODS

Context and data

The reported study is a part of the Finnish national Flexible Equation Solving programme (2014–2019). Two consecutive lessons of different nature from the 9-lesson pilot study for 7^{th} graders in 2015 were selected for further analysis:

Lesson 4: Equation Solving (ES)
Lesson 5: Reversed Equation Solving (RES)

In the lessons, students were seated in groups and were asked to work on the assignments together (teacher facilitation was mostly absent in these small groups). During ES (lesson 4) students solved equations in groups whereas in RES (lesson 5) students created equations in groups, shared them on the blackboard with their names, solved each other's equations and compared their work. The equations were created by choosing a starting point (e.g. 5 = t) and operating on both sides (more about Reversed Equation Solving in Tuomela, 2016).

In this study, we focus on two small groups of four students who worked actively during both lessons. The both groups consisted of one mathematically strong, one weak and two average students. Data was collected by video recording the work of the two groups using two video cameras. The time for group work was 18 minutes in lesson 4 and 15 minutes in lesson 5.

Data analysis

The research strategy was to 1) create categories describing students' engagement during interaction, 2) form engagement profiles for each student and group and 3) interpret the differences between lessons. In line with directed content analysis (Hsieh & Shannon, 2005), indicators of cognitive engagement were defined based on previous research (Helme & Clarke, 2001; Fredricks, Wang, et al., 2016; Asterhan & Schwarz, 2009). Definitions, examples and coding rules for the categories were collected in a coding agenda which is summarized in Table 1.

Category	Description
Ask	Asking a task or working strategy related question.
Help	Helping a peer. Typically stating an answer or showing a notebook.
Idea	Sharing ideas, suggesting next steps or reflecting on mathematics.
Conc	Concentrating. Mumbling calculations aloud or resisting distractions.
Resp	Task related short response like yes, no, nodding or a simple opinion.
Chal	Challenging. Showing signs of disagreeing or asking for explanations.
Just	Justifying an idea or statement.

Table 1: Indicators of cognitive engagement. Short descriptions of categories.

The coding agenda was refined during the analysis. Formative checks of reliability and coding iterations were done. Throughout the process, definitions and coding rules for the categories were discussed between researchers.

RESULTS

We found two different working modes in small group work: students concentrating on their individual work and students working collaboratively thinking together. First, we elaborate on the two working modes using example episodes. Then, we examine how the amount of indicators of cognitive engagement changed from lesson 4 (ES) to lesson 5 (RES).

Individual and collaborative working modes

The first episode illustrates individual working mode. In the episode, students in group A were solving equations during lesson 4 (ES).

1	Anna:	I don't get it.. [unintelligible]
2	Eve:	Poor you… [indifferent tone]
3	Eve:	I like these a lot, these where we need to calculate
4	Anna:	How can the first one be solved? (Ask)
5	Eve:	I don't know. I jumped to this block, because here I can multiply all numbers by two. [pause]
6	Eve:	That would be also... [unintelligible] [pause] (Conc)
7	Eve:	[mumbling by herself] 6a... [pause] (Conc)
8	Eve:	[mumble] Add both sides... [mutters calculations aloud] (Conc)
9	Anna:	Don't do it so fast...
10	Eve:	Oh, sorry… [grinning indifferently] [long silence]
11	Eve:	[mumbles calculations] ...Yes! (Conc)
12	Eve:	What, did you drop off the sled somewhere? [sly grin] (Ask)
13	Anna:	May I look at it…? (Ask)
14	Eve:	Sure, feel free... [still grinning] (Help)
15	Anna:	Well, here was the mistake… (Idea)

This example shows that although the students were working in a group, they were engaged mostly to their own work (turns 5, 6-8, 11). When they were talking, authority was clearly present because they asked for help (4, 13) and provided help (14) in a simple copying manner instead of sharing their thinking, reflecting on mistakes or making decisions together on the same level.

The second episode illustrates collaborative working mode. In the episode, students in group B were creating an equation during lesson 5 (RES).

1	Anni:	Let's take turns to pick one [transformation]. (Idea)
2	Anni:	Let's do four of em'. (Idea)
3	Anni:	So I will… multiply by seven. (Idea)
4	Lassi:	Add… No… Leo's turn. (Idea)
5	Lassi:	What shall we do? (Ask)
6	Leo:	Multiply… (Idea)
7	Anni:	No… No but… (Resp)
8	Anni:	You shouldn't multiply anymore… (Chal)
9	Anni:	It just becomes the same kind of. (Just) [12 utterances skipped]
10	Anni:	So $7x + 6 = 21 + 6$ [erases right side] so 27 [writes $7x + 6 = 27$] (Idea)
11	Anni:	[Anni and Suvi compares their work] Like this. (Help)

12 Suvi: What…? Aaaa!!! [notices a mistake: $7x + 6$ became $13x$] (Resp)
13 Anni: Because they cannot be comb… (Just)
14 Suvi: Why don't they put those separately? [points right side of equation] (Ask)
15 Anni: Because here it doesn't have either... [points left side] (Just)
16 Lassi: So is it…? [simultaneously with Suvi] (Ask)
17 Suvi: How about that one? [simultaneously with Lassi] (Ask)
18 Anni: There isn't. (Help)
19 Anni: You cannot combine them because there is x. (Just)
20 Suvi: Oh, that's true! [hitting her palm to her forehead and laughing] (Resp)
21 Anni: I made the same mistake earlier!! Really! [laughing] (Idea)
22 Lassi: Right then, this is… Is this now a good equation? (Ask)
23 Anni: No, still 2 (transformations) (Resp)
24 Suvi: I haven't decided yet…
25 Anni: And Lassi neither.
26 Anni: Right. Substract, multiply, divide, add… (Help)
27 Anni: Let's not add… (Idea)
28 Anni: Let's agree you cannot use the same transformation twice in a row. (Idea)

Throughout this episode students frequently shared their ideas (1-4, 6, 10, 27-28), justified (9, 13, 19) and asked questions (5, 14, 16-17, 22) in a productive way that built their understanding or moved forward the assignment. While doing this, they often used the words "Let's" and "we" showing how they were working on it together (1-2, 5, 27-28). They also made sure that everyone in the group became involved in the process (1, 4, 24, 25).

The chosen episodes also illustrate the different nature of the two small groups. The most active person in group B (Anni) was an empathic leader who involved others (1) as well as regulated group actions and atmosphere (2, 8, 21, 23, 25, 26-28). In contrast, the most active person in group A (Eve) was not so sensitive towards other group members (2-3, 10, 12) and concentrated mostly to her own work.

Changes in indicators of cognitive engagement

The amount of indicators of cognitive engagement for students in group A as well as for groups A and B are presented in Table 2. To save space, the individual student data from group B was omitted. According to table 2, lesson 5 (RES) contained more interactions related to collaboration (Ask, Help, Idea, Resp) and less muttering calculations aloud (Conc) than lesson 4 (ES). This implies a change from individual working mode towards collaboration. In other words, type of engagement changed as the groups were more engaged to collaborative work in lesson 5 (RES) than in lesson 4 (ES). This happened regardless of the previous amount of collaboration and the different climate in the groups.

		Ask	Help	Idea	Conc	Resp	Chal	Just	Total Engagement
Eve	ES	7	14	6	30	2	2	3	64
	RES	13	13	13	3	17	2	0	61
	RES-ES	6	-1	7	-27	15	0	-3	-3
Kim	ES	5	1	2	9	1	0	0	18
	RES	21	3	5	5	13	0	0	47
	RES-ES	16	2	3	-4	12	0	0	29
Anna	ES	11	0	3	4	3	0	0	21
	RES	10	3	6	1	5	1	0	26
	RES-ES	-1	3	3	-3	2	1	0	5
Tuomas	ES	0	0	0	0	0	0	0	0
	RES	4	5	9	1	3	0	0	22
	RES-ES	4	5	9	1	3	0	0	22
Group A	ES	23	15	11	43	6	2	3	103
	RES	48	24	33	10	38	3	0	156
	RES-ES	25	9	22	-33	32	1	-3	53
Group B	ES	46	14	46	46	36	8	5	201
	RES	45	21	81	42	63	10	10	272
	RES-ES	-1	7	25	-4	27	2	5	71

Table 2: Amount of indicators of cognitive engagement in each category.

During ES, two students showed no indicators of cognitive engagement and three students showed about 20. These five students are considered passive. Three of them showed 20-50 indicators of engagement more during RES. It should also be noted that the increased engagement for groups is mostly due to the awakening of these passive students. Table 2 indicates the changes for the passive students of group A (Kim, Anna and Tuomas). Both groups had also students whose total engagement did not increase much (Anna and Eve for group A), although the type of engagement changed.

DISCUSSION

Two clear differences in students' engagement were found when observing two small groups during two different kind of algebra tasks. Firstly, students' type of engagement changed from individual to collaborative. They started sharing ideas, opinions, and questions during RES (lesson 5) when compared to ES (lesson 4). Secondly, three passive students during ES became clearly more engaged during RES.

Considering the type of engagement, as suggested in this study, is important because previous studies have found that in effective small groups students use talk in which they share emerging ideas, explore each other's ideas and challenge ideas (Mercer & Howe, 2012). This means that effective small groups engage in collaboration. Thus, the distinction between individual and collaborative engagement helps to make sure that students are not only engaged but engaged in collaboration. Furthermore, interventions like Reversed Equation Solving combined to discussion about individual and collaborative type of engagement could be used to raise teachers' awareness of different types of student engagement and of engagement-supportive practices as called for by Skilling, Bobis, Martin, Anderson and Way (2016).

The results imply that only the task (without much teacher facilitation) can dramatically change the nature of peer-to-peer interactions from individual working mode into collaboration and awaken passive students. Several characteristics of Reversed Equation Solving may account for this. Firstly, the assignment requires the students to create something of their own and allows use of creativity. Secondly, it requires the students to make decisions together and to agree on next steps. Thirdly, students publish their work to the whole classroom and get feedback of their work from other students. Fourthly, when students create their own tasks, the difficulty level is adjustable, while on the other hand whole-class publishing encourages the students to try something novel or tricky. Also previous studies suggest that engagement is related to novelty of task (Helme & Clarke, 2001) and supporting student autonomy (Skilling et al., 2016). Henningsen and Stein (1997) emphasize that it is important to use demanding tasks and to maintain engagement in them instead of using easier tasks. RES is a good example of this in the context of algebra. Thus, this study contributes to the conquest of finding out how to engage through content and discovering characteristics of algebra tasks related to engagement (Nyman & Kilhamn, 2015).

Video analysis methods allow studying engagement in detail both in group and individual level. The results reveal the importance of looking at individual changes. If only changes in group level had been observed, then it would have gone unnoticed that it is actually due to only three students becoming more engaged and the rest not becoming more engaged (although type of engagement changed). Thus, this study points to the importance of considering the complexity of individual and social processed underlying engagement as called for by Järvelä, Järvenoja, Malmberg, Isohätälä and Sobocinski (2016). Video study of engagement has also challenges. Regarding passive students it could be asked if the change was actually increase in engagement or just engagement becoming visible. This kind of analysis did not reveal any information about those students' level of engagement who were silent.

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