Presented in Knowledge Building Summer Institute (Toronto, August 14th to 17th 2018)

Exploring the contribution of students with learning difficulties in an inclusive co-invention project

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Abstract: This study investigates the contribution of students with learning difficulties (LD) in a co-invention process where a student team (Grade 6) generated ideas, constructed their own inventions, and evaluated the functionality of the inventions in close collaboration with their team members. In this preliminary analysis, we report on the experiences of three LD students when working in a 'gel comb' invention team. According to the interview data, the students viewed the project as beneficial. Two main themes emerged from the preliminary qualitative content analysis: peer- and teacher-supported collective responsibility and the relevance of the invention for shared agency.

Introduction

Inclusive education, where students with identified learning difficulties (LD) learn as full members of the group, has been one of the central aims of educational polices since the Salamanca Statement (United Nations Educational, Scientific, and Cultural Organization, 1994). In Finland, The Basic Education Act (642/2010) obligates schools to organize educational support for students' growth, learning, and school attendance, including students with mild and severe LD. In fact, intensified or special support was received by 16.4 percent of comprehensive school students in Finland in autumn 2016 (Official Statistics of Finland, 2017). Recent studies have indicated that many teachers face problems when implementing inclusive education in classrooms both in Finland (e.g. Paju, Räty, Pirttimaa, & Kontu, 2015) and in other countries (Bešić, Paleczek, Krammer, & Gasteiger-Klicpera, 2017). In addition, there are worrisome observations that LD students are generally less accepted by their peers, which has a negative effect on their self-concept (Pijl & Frostad, 2010). However, the pursuit of meaningful learning challenges and mutual peer support facilitates and engages LD students in learning (Scruggs, Mastropieri, Bakken, & Brigham, 1993). Some investigations indicate that students with diverse styles of or orientations towards working often collaborate productively, and this may provide an encouraging example to LD students (Tomlinson et al., 2003). Pedagogic support that is responsive to learners' varying readiness, interest, and skills is needed (Brigham, Scruggs, & Mastropieri, 2011; Tomlinson et al., 2003).

The basic tenet of our investigation is that LD students can productively participate in knowledge-creating learning practices (Hakkarainen, 2009; Paavola & Hakkarainen, 2014) in terms of taking part in learning and knowledge-building efforts and the associated peer collaborative processes. In knowledge-creation practices, every team member is encouraged to contribute their knowledge to the shared epistemic object (e.g. Damsa et al., 2010; Hakkarainen, 2009). In addition, LD students may take part in a knowledge-creation process and assume collective cognitive responsibility for developing their joint object of inquiry. This entails every student, including LD ones, contributing to knowledge improvement (Scardamalia, 2002). The involvement of students with special educational needs is an important aspect of democratizing knowledge; by taking part in a joint knowledge-creation process they may gain a strong sense of contribution and earn social recognition for their achievements. Knowledge-creation is a nonlinear and emergent process (Scardamalia & Bereiter, 2014), which means LD students may need a great deal of support and structuration. This does not, however, mean going back to closed, linear, and scripted learning processes, but rather involves providing real-time support and scaffolding according to the emergent situational needs (see also Viilo, Seitamaa-Hakkarainen, & Hakkarainen, 2017). The purpose of the present study is to investigate LD students' experiences of participation in knowledge-creation based co-invention challenge, and to contribute to this area of research. The research questions are: 1) What were LD students' views of their contribution to the co-invention process? 2) How was the LD students' contribution supported in the co-invention process?

Method

Research setting and participants

The co-invention project was organized in two cycles in spring 2016 and spring 2017 in a primary school in the capital area of Helsinki, Finland. Forty-two sixth graders, aged 12 to 13, participated in the project. The co-invention challenge, with the theme Everyday Activities, was designed by a team of teachers (two class teachers and one special education teacher) and researchers to integrate science, craft, arts, mathematics, and history content. The actual design task for the experiment was based on the student teams' analysis of daily activities and everyday tools. Students were asked to improve a tool or to invent a new one to make the daily activity easier. Their aim was to design an intellectually challenging, aesthetically appealing, and personally meaningful complex artefact that integrated physical and digital elements (e.g. circuits or robotics). The students formed 13 teams to work on their inventions. Table 1 presents the structure of the co-invention project.

Table 1: Schematic structure of the co-invention project.

	Spring 2016; Cycle 1	
Phase	Description of activities	Duration
Orientation	Students analyzed existing artefacts and their uses with a real-life expert designer, made notes, and became familiar with design processes.	1 session; 90 minutes
Skill building	Students practiced using various technological tools, and techniques (21st Century note booking, coding with Lego robotics, and GoGoBoard) were presented.	3 sessions; 90 minutes each
Co-design brief and design constraints	Students brainstormed the ideas in groups in school and with parents at home. Students grouped the ideas and defined users, needs, and functions.	2 sessions; 90 minutes each
Science practices	Students evaluated the properties and behavior of the materials and designs used in similar artefacts.	1 session; 90 minutes
Design practices	Students analyzed the design constraints related to material properties and structural and functional features. Student teams presented their ideas and plans to the whole class, and received peer feedback through an electronic form.	1 session; 90 minutes
Knowledge seeking	Students made visits to off-school sites to gather information and to familiarize themselves with materials not available in the school.	Half-day trip; approx. 120 minutes
Experimenting	Students explored and experimented with their design solution and with the physical properties of its materials (e.g. durability, insulation, structural stability, functional adequacy).	2 sessions; 90 minutes each
MakingLab	Students constructed models (from paper, clay, etc.) and experimental prototypes (mock-ups).	3 sessions; 90 minutes each
Exhibition	Student groups created poster, PowerPoint, or video presentations to share their designs with an audience (parents).	60 minutes
	Spring 2017; Cycle 2	
Orientation	Students analyzed the inventions they had produced the previous spring. Students made plans for alterations and the required science and design practices.	1 session; 90 minutes
Skill building	Teachers explained how to use the class's digital learning environment for collaborative knowledge building.	½ session; 45 minutes
Experimenting and MakingLab	Students shared ideas, explored and experimented with their design solution, and constructed prototypes.	8½ sessions; 90 minutes each
Exhibition	Student groups created poster, PowerPoint, or video presentations to share their designs with an audience (other inventors, teachers, university staff).	120 minutes

The present investigation focuses on examining one team and gathering the participating LD students' views at the end of the process. The team was chosen because of its participant structure (two mainstream and three LD students). Their invention was a gel comb for boys who want to gel their hair quickly without getting their hands dirty (Figure 1). The gel comb looks like a normal comb, but it has a container in which the gel is stored and then pressed through comb spikes and into the hair. The team made five different prototypes from wood (black in Figure 1), recycled materials (yellow, green, and blue), and 3D printing (white).

Figure 1. Prototypes of the gel comb.

Data collection and analysis

Before the second cycle in spring 2017, the teachers' perceptions of LD students' learning was reviewed during video-recorded sessions. All of the gel comb team members (Elias, Juhani, Leo, Mikael, and Olavi) were interviewed individually at the end of the project in May 2017. Structured interview guidelines were drawn up, including general and follow-up questions based on three themes: background (general opinions on learning, technology, and team work), invention (depiction and process), and team work (group organization and reflection). The corresponding author conducted the interviews on a one-to-one basis following the stimulated recall method. We applied Tochon's (2007) notions on viewing past events to remember one's past thoughts using the notes, and photos, taken by the team during the project lessons as a stimulus to help them recall. In order to collect high-quality data from the LD students, it was essential that the researcher knew them well (Stake, 2005; Stalker, 1998). The corresponding author was present at every session; this familiarity increased confidence among the LD students (Stalker, 1998).

Table 2: Analyzed students' ages, learning difficulties at school, attitude to team work, and transcribed interview data (in number of words).

Student (pseudonym)	Age	Teachers' view of learning at school	Attitude to team work	Data
Elias	12	Diagnosed with mild mental retardation. Difficulties appear as slowness, reluctance to work with strangers, and a tendency to retreat.	Difficulties in naming positive or negative aspects of team work. Likes to work in a team if other members are familiar to him.	2316 words
Juhani	12	Mainstream student	Likes to work in a team because it is more productive. Working with familiar persons is easier for him.	1990 words
Leo	12	Mainstream student	Likes to work in a team because tasks are shared. Often organizes tasks among team members.	2906 words

Mikael	13	Diagnosed with ADD (attention deficit disorder without hyperactivity). Difficulties appear as needing teacher support, the teasing of others, and ignoring school duties.	Likes to work alone rather than in a team because it is easier to concentrate when working alone.	2325 words
Olavi	13	Diagnosed with ADHD (attention deficit and hyperactivity disorder). Difficulties appear as a lack of concentration.	Likes to work in the team but feels that sometimes it is difficult to participate. Feels that in a team it is easier to get help and use own strengths.	2604 words

At the beginning of the data analysis, the description of participating students was drawn up based on the interviews with teachers and students (Table 2). The recorded interview data was transcribed and coded using the Atlas.ti software. In this preliminary analysis, we decided to focus closely on the LD students in order to understand their needs and experiences better. The mainstream students' data was also analyzed, but not as thoroughly as that relating to the LD students, which was systematically analyzed using theory-based coding. The categories 'collaboration,' 'LD support,' and 'co-invention process' were defined beforehand, based on previous research literature (e.g. Brigham, Scruggs, & Mastropieri, 2011; Johnson & Johnson, 2013). During the coding process, the categories were refined into three main categories of 'collaboration,' 'competences,' and 'invention,' including nine sub-categories and forty codes. In Atlas.ti, we ran the basic analyses of codes and their co-occurrence. In what follows, the preliminary findings are presented together with illustrative quotations from the interviews. Two main themes emerged from the data analysis: peer- and teacher-supported collective responsibility and the relevance of the invention for shared agency.

Preliminary findings

Peer- and teacher-supported collective responsibility

All students had a positive attitude to team work (Table 2), and the interviewees mentioned that shared responsibility was its most beneficial element. Almost everyone thought that working with friends of other familiar people was easier for them. However, the LD students had different general opinions on their collaborative learning activities. Elias felt that working in a team was easy, especially if he was working with a friend who he knew beforehand. However, Mikael thought he concentrated better when working alone, and said that focusing on a task was difficult if he had a friend in the same group. Olavi felt that participating was sometimes challenging if the other team members were ignoring him or if he did not know how to participate. Even though the LD students' general opinion of collaborative activities at school differed, their experiences of this co-invention project were only positive. Inside the team, students formed three work pairs. Olavi helped Leo to organize the group's tasks. When everyone knew what to do, Olavi and Leo worked on different areas based on whatever needed to be done. Mikael made prototypes with Juhani, and Elias drew sketches of different prototypes. In general, all three LD students felt that collaborative learning was easier for them because of the shared responsibilities involved and the ability to utilize each member's strengths.

Throughout the interviews, all students talked of 'we' instead of 'I' when describing the co-invention process. In general, the mainstream and LD students had different views of organizing the work at the beginning of sessions. The mainstream students saw that they shared tasks and made decisions collaboratively. For example, Juhani said that 'we always discussed what we should do. If we couldn't decide or divide tasks ourselves, [the] teacher helped us.' Leo pointed out that his role was 'to take care of dividing [the] tasks,' and mentioned the teacher's role in supporting the team. For him, knowing that the teacher's support was available was enough. Indeed, the mainstream students mentioned only teacher support, and never peer support, while the LD students felt they benefitted from peer and teacher support, although peer support, and especially Leo's support, was mentioned more often than that of teachers.

> Interviewer: What kind of help did you need and get?
> Olavi: I got guidance [on] what to do, and [on] what the general idea of it was [the invention].
> I: Who gave you guidance?
> O: The teacher, Leo, and Mikael. And then Juhani and Elias gave some more.

The group roles that Leo set at the beginning of each session seemed to be beneficial for all LD students. The clear group roles appeared multiple times, together with the codes 'decision making' and 'dividing tasks.' It seems that the clear group roles made cooperation feel easier, which was relevant for the LD students' collective responsibility. All of the LD students experienced working alone as being more difficult for them. For example, Elias thought that when ‘working with familiar persons, the learning tasks are much easier. It gets more difficult if I’m working alone.’ Olavi on the other hand described the benefits of team work: ‘You get support and you can help others in tasks in which you are good.’

It was evident that the gel comb invention team had a recognizable leader. In addition to organizing team work, Leo was the dominant member, with the ability to form a clear picture of the design ideas, participate in all tasks, and spur everyone to contribute.

> Interviewer: How did you get to these solutions?
> Mikael: Don’t ask me, ask Leo.

Inventions as drivers for shared agency

During co-occurrence analysis, we identified the importance of the shared object for all of the LD students. First, most of the quotations in the data were invention related; the clear group roles, support, and productive work co-occurred multiple times in describing the invention. Differentiated tasks, the necessary support, and the ability to contribute seemed to be committing factors for the LD students. Although Leo was named as orchestrator, all interviewees knew how the gel comb was supposed to work; they were also able to explain the difficulties they faced when building the actual mechanism. All of the LD students felt that the malfunctioning invention was a success rather than a failure.

> Olavi: We made a prototype at least, and we did our best.

The mainstream students talked more about the malfunctions of the invention and reflected on what the group could have done differently. Juhani explained that ‘sometimes we just chatted and goofed around…we didn’t get anything at all done.’ Leo had a similar view, as he thought that the team ‘worked well sometimes and [at] other times poorly.’ Overall, Leo thought they ‘had a lot of fun working together…We could have succeeded better with [a] different group. Now we just thought that this is fun.’

Competence-related issues were also identified from the LD students’ interviews, where invention co-occurred with attitudes to working and working skills several times, especially in terms of problem-solving and decision-making skills. In addition, shared agency was noticeable when the LD students talked about their role in the process (see above). This knowledge-creation project engaged all of the LD students in learning. Olavi and Mikael also considered it beneficial for their future.

> Interviewer: What have you learned in this invention project?
> Olavi: That it is worth [putting] effort [in] to do things.

Conclusions and discussion

The purpose of this study was to investigate whether LD students can productively participate in a knowledge-creation based co-invention project. We attempted to respond to findings from previous studies where schools had difficulties in implementing inclusive education (e.g. Paju et al., 2015; Bešić et al., 2017) and promoting peer acceptance in inclusive classes (Pijl & Frostad, 2010). Our preliminary analysis provides promising insights into LD students’ productive participation when working on a shared epistemic object (Hakkarainen, 2009). In the gel comb team, the innovation was a driving force for all students. However, the need for support was evident, especially in terms of the LD students having a clear role in the team and the commonly recognized leader-enabled positive and genuine social participation. From the LD students’ point of view, the co-invention challenge improved their attitudes towards collaborative tasks. Furthermore, in this investigation, the mainstream students focused on ‘invention’ instead of the LD students’ disabilities. Working as full members of a group could promote LD students’ social acceptance by peers, and therefore promote inclusion.

The need for differentiation is prominent with LD students. Our study increases the understanding of at what point of the process structuration is needed, and of when the student group needs teacher support and when the group members can support each other. Collective cognitive responsibility drives students to support each other, but teacher assistance is also required. Transferring from solely teacher-orchestrated learning to collective knowledge-creation practices might be more beneficial to LD students’ sense of belonging, which could have a positive effect on their self-concept. It is evident that this investigation serves merely an analytical model for more profound analysis. In the next phase, we investigate other invention teams involved in this co-invention project. However, further studies in other schools and with different projects are required.

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Acknowledgments

This material is based upon work supported by the Academy of Finland grant 286837 (Co4-Lab) and Strategic Research Council grant 312527 (Growing Mind). The opinions expressed here are those of the authors and do not represent the views of the funding agencies.