

Knowing Together - Sharing Artefacts in Struggling Groups

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Abstract

In this doctoral project, I seek to investigate the relationship between artefacts, group compositions, and groups' interactions when they are uncertain in their lab-based group work. The project lies in the intersection between computer-supported collaborative learning and science education, as it seeks to identify patterns of participation in group work based on knowledge artefacts. The project utilises sensors to collect data, which is triangulated with video and audio recordings, and the data stems from school classes who participate in a one-day activity at a science centre. The output should inform the creation of a learning analytics system and contribute to a deeper understanding of the connection between artefact use and constructive group interactions.

Keywords

Multimodal Learning Analytics, group work, Exploratory Talk

1. Introduction

Learning involves navigating uncertainty, grappling with doubt, and occasionally encountering failure. While this is true for most learners, people are less likely to learn from their own mistakes, particularly when their ego is threatened [1]. This echoes in schools, where the PISA 2018 showed that half of the surveyed pupils report fear of what others think of them when they make errors [2]. This challenge affects education broadly, but it becomes particularly pronounced in science teaching. School science suffers from being perceived as dull, foreign from 'real' science, and as having an emphasis on getting the right answer [3], [4].

Group work provides an effective instructional format where individual responsibility for suggestions and uncertainties can shift to the collective, potentially allowing pupils to inter-think without the fear of being wrong [5]. Fostering a learning environment that can prosper such collaborations has the potential to allow pupils access to learning science, who might normally hesitate due to fear of being wrong.

Productive collaborations are thereby marked by how individual contributions are received in the group. Cognitive- and social processes intertwine at the group level, as both

LASI Europe 2024 DC: Doctoral Consortium of the Learning Analytics Summer Institute Europe 2024, May 29-31 2024, Jerez de la Frontera, Spain

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are essential to the functioning of the group [6]. In science teaching in physical spaces, group members' contributions are influenced by their access to knowledge artefacts central to the task. The *knowledge artefact* is thereby the artefact necessary to solve a given task, such as a microscope for doing microscopy. The task and design of knowledge artefacts impact their shareability within groups. Factors include simultaneous access (whether multiple people can use the knowledge artefact at once) and task structure (whether the task encourages collaboration).

My doctoral project aims to explore how group-level compositions of how pupils to participate in their group work (might) enable the group to engage in inter-thinking when they face problems or uncertainties in their science experiments. I base the group-level compositions of ways to participate on an initial exploratory field study of 14 different classes at a science activity centre. I will use this classification to compare behavioural patterns of how groups face problems in different activities during their visit to the activity centre.

One aim of my project is to inform the creation of a learning analytics system, grounded in a study of the specific activity centre and its tasks. While co-located collaboration is a recent addition to learning analytics, a wide variety of sensor-based measures have already been pushed forward [7]. Defining effective collaboration analytics remains challenging due to the multifaceted ways that group work is implemented as a teaching format [8]. Praharaj and colleagues further explore this complexity by investigating the connections between collaboration indicators, quality measures of collaboration, and the impact which scenario-based goals and parameters have on the indicators' relevance [9]. As one of their examples, they contrast the quality indicators of collaboration in gaming tasks and in brainstorming tasks, revealing significant differences. In the existing literature, Praharaj and colleagues find a scarcity of operationalisations of indexes and task goals which they argue need to be strongly connected when designing learning analytics.

1.1. Problems, Groups, and Knowledge Artefacts

My doctoral project is based on an important assumption: problems have educational potential as a means for pupils to engage with learning content through reflection on what the problem consists of (e.g., Schön, 1987). Productive failure, or the idea that spending time on open-ended problems can allow pupils to discuss the limits of a problem, has been found to have positive effects on pupils' long-term learning [11]. Identifying how pupils can engage productively with uncertainties in their artefact-based group work is therefore important for understanding how pupils might engage in meaningful problem-solving conversations in the physical classroom.

An essential part of discussing what a problem consists of is contrasting and comparing different solutions. Exploratory talk is a characterisation of talk that allows pupils to do so, by engaging with others' ideas in groups [5], [12]. Key elements of exploratory talk are the open discussion and challenge of arguments, and the invitation of other perspectives [5], [12]. Several articles suggest that the use of artefacts and tools is important for how this can happen [13], [14].

1.2. Connecting Artefacts and Group Work

While exploratory talk was initially studied as a verbal phenomenon, subsequent work has explored how group members' use and sharing of various tools align with exploratory talk. For instance, this alignment is evident in the difference between group work based on all-participating-at-once at interactive tabletops vs turn-taking when groups use single iPads for group work [15]. Group members' access to information on their screens are thereby part of constructing the conversations, whereby the knowledge artefact's design will enable different conversational patterns. This underscores the significance of bodies and the near-material sphere for understanding how collaboration is situated around tools in education [16], [17].

Different frameworks have emerged for investigating the relationships between knowledge artefacts and individuals in CSCL. In a comparison between affordances, structures, and instruments, Overdijk and colleagues highlight the usefulness of instrumental genesis as a way to address the mutual shaping of human agents and technical artefacts [18]. In this work, I seek to connect the idea of instrumentation to the argument from Fleck and colleagues, to make the argument that knowledge artefacts and groups' understanding of them, will impact how they share potential solutions when they feel insecure about their tasks.

2. Objective and Research Question

This doctoral project aims to explore the relationship between pupils' access to shared knowledge artefacts and their contributions to the group work both through verbal- and embodied interactions. I employ a combination of ethnographic- and trace-based methods (pupils' position, orientation, tools use, and audio). The goal is to uncover how groups' sharing of knowledge artefacts in science creates different possibilities for interactions. One objective is to use these insights to inform the design of a learning analytics system.

The project is situated in a Danish science activity centre that hosts school classes to participate for one day in different learning activities. The class is divided into groups of 2-4 pupils, and I investigate their participation in three distinct activities: 1) programming an automatic watering system, 2) examining plant samples under a microscope, and 3) conducting an experiment measuring bacteria growth.

By investigating group work in artefact-based science activities, I aim to shed light on how different knowledge artefacts enable distinct ways of solving uncertainties as they arise in the groups. Getting to share uncertainties in groups can potentially reduce the fear of failure among the pupils in the groups.

2.1. Research Question

I formulate the project about the following research question: How are physical knowledge artefacts part of pupils' collaborations in their lab-based group work, and in what ways are they enabling or hindering pupils' creation of common solutions to arising uncertainties in their work?

To address this question, I have formulated the following sub-questions on key parts of the project:

- Collaboration patterns and artefacts: What collaboration patterns are the artefacts part of establishing in the pupils' group work?
- Common ground and uncertainty: How are groups (re-)establishing common ground when facing uncertainty?

3. Methodology and Methods

In my doctoral project, I have structured my work into three phases: an ethnographic phase connected to situating the knowledge artefacts and outlining the collaborative patterns at the learning centre, a quantitative-ethnographic phase in which I connect the knowledge artefacts and collaborative patterns to quantitative sensor data from the lab, and finally, a comparative phase, in which I contrast patterns across a higher number of school classes to compare the effect of different group constellations (e.g., based on friends, based on experience).

Ethnographic:

In the initial phase, I am using ethnographic field-notes from 14 observations to investigate how the artefacts are situated within the learning activities, and in what ways pupils can contribute to the group work. I am working with the fieldnotes in a grounded theory framework [19], using constant comparisons to investigate it. In my analysis, I have a focus on the materials and on the symbolic interactions from the group members.

Quantitative-ethnographic:

In the second phase, I am using audio-, video-, and trace data from pupils' positions and orientation from ~20 school classes. I will work with quantitative ethnography [20] to compare how groups communicate about different types of tasks, with different artefactual setups. I will also use the grounded theory framework from the prior phase to compare different types of group constellations, and how these affect the building of common ground.

Quantitative Comparison:

In this final phase, I will seek to compare the position, orientation, and audio features of group conversations from ~50 school classes to investigate the effect of different group constellations on the pupils' use of exploratory talk and their building of common ground when facing problems. This will be based on a randomised clinical trial, in agreement with the activity centre. I will then compare key variables, as the duration of exploratory talk (and movements) in a multi-level regression [21]

To collect audio-, position, and orientation trace data, our research project is developing a business-card-sized technology to use in the lab, named mBox (Li et al., 2024). Collecting

data from sensitive populations, such as children in secondary schools, raises ethical questions about informed consent, and data usage and storage. We are collaborating with the science centre to gain consent from the parents and are using a closed-loop system for data collection and processing. For the project's third part, we aim to make the badge system collect only patterns of audio and position. This lightweight transformation of the data will make the observations anonymised.

4. Results

My doctoral project is still in its early days, as I started my position in the fall of 2023. I have mapped out the following milestones since the start:

- I have, with colleagues, submitted a paper that seeks to map the field of literature which utilises quantifications to investigate small-scale group work in education.
- I have conducted two small-scale experiments with the badges. Utilising the data from the small-scale experiments, I have, together with colleagues, created a workshop for discussing multimodal analytics on co-located collaboration for ~100 participants.
- I have observed teaching at the activity centre with 14 different classes (~84 hours)
- I have conducted video ethnography of the initial three classes.

5. Limitations and Future Work

The 'future work' section of this proposal could be rather long, due to the recent start of my work. I will however limit it, to be in dialogue with the potential limitations from my work for the objective of creating an outcome that can inform a learning analytics system on the productivity of groups to share knowledge when facing uncertainties. While my design can enable deep knowledge of the relationship between knowledge artefacts and groups, it will not give insights into how to inform groups and/or their teachers about these insights. A next chapter would be needed, to create meaningful feedback in the learning situation.

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