Collaborative Learning as a Sustainable Structure of Teaching Practice for Supporting Mathematically Highly Able Students

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and Computer Science

Working Papers in
Mathematics Education

Karlstad University | 2020:1

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urn:nbn:se:kau:diva-81887

ISBN 978-91-7867-161-8 (pdf)

Distribution:
Karlstad University
Department of Mathematics and Computer Science
651 88 Karlstad
054 700 10 00

Print: Universitetstryckeriet, Karlstad 2020

WWW.KAU.SE

Förord

I denna artikel i rapportserien Working Papers in Mathematics Education publiceras den text som låg till grund för Elisabet Mellroths presentation som inbjuden talare i arbetsgruppen *TSG 3. Mathematics education for gifted students* vid *14th International Congress on Mathematical Education* i Shanghai sommaren 2020. Konferensen blev framflyttad till 2021 men Elisabet valde att dra tillbaka sin presentation och text på grund av osäkerheten kring Covid-19 i världen.

Texten är relaterad till ett projekt vid Örebro universitet om kollegialt lärande bland gymnasielärare i matematik där ett delsyfte är att utveckla matematikuppgifter som ska ge utmaningar till alla elever inklusive de som är särskilt begåvade. I texten ges argument för kollegialt lärande som en hållbar metod att utveckla lärtillfällen för elever med särskild begåvning. Projektettiden är augusti 2019 - december 2021,

Elisabet riktar ett varmt tack till Andreas Bergwall som är hennes kollega i projektet vid Örebro universitet.

COLLABORATIVE LEARNING AS A SUSTAINABLE STRUCTURE OF TEACHING PRACTICE FOR SUPPORTING MATHEMATICALLY HIGHLY ABLE STUDENTS

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Inclusion of gifted education in teacher education is not common in Sweden or in many other European countries. As a result, many teachers lack knowledge of teaching highly able students. Most teachers do want to learn and develop this area of their teaching but, when teaching schedules are full, little time is available for ongoing professional development. A process in which professional development is intertwined with teachers' daily work is needed, to ensure sustainable changes of practice. Teachers' collaborative learning is an activity in which teachers collaboratively and systematically analyze their teaching, with the aim of developing their practice. This paper is based on an ongoing study, which explores how a group of mathematics teachers use principles of such collaborative learning to develop their own knowledge of educating and supporting students highly able in mathematics. This study indicates that collaborative learning provides a promising process for sustainable changes in teaching practice that can in turn provide highly able students with learning opportunities.

INTRODUCTION

It is rare that Swedish teachers have undertaken professional development on gifted education (Mattsson, 2013). Lack of knowledge about gifted education among teachers seems to be a problem not only in Sweden, for example Shayshon, Gal, Tesler, & Ko (2014) conclude from their studies that teachers need more professional development on how to include students with high ability in mathematics in teaching. Not surprisingly, many studies have shown that highly able students are seldom given learning opportunities that develop their knowledge (e.g., Leikin & Stanger, 2011).

However, there are promising examples of how perspectives of gifted education can be included in teachers' professional development (Mellroth, van Bommel & Liljekvist, 2019; Mellroth, 2020). This paper focuses on teachers' collaborative learning, in parallel with their regular ongoing teaching practice, as professional development to develop teaching skills for including highly able learners in teaching. Mellroth (2018) indicates that collaboration between teachers is a core-criteria when it comes to developing teaching skills to identify and support highly able learners in regular classrooms. In addition, Mellroth et al. (2019) showed that teachers themselves perceive teacher collaboration as necessary to in practice include highly able learners in teaching.

This paper refers to a study in which eight teachers of mathematics at upper secondary school level (years 10-12) participated in collaborative learning with an aim to develop a digital source of challenging tasks connected to the Swedish curriculum. Part of the aim was to develop better learning opportunities for students with high ability in mathematics. At the time of writing this paper, the study is in its initial phase.

The guiding question for this paper is: How can teachers' collaborative learning be a process for developing practice to improve teaching for students with high ability in mathematics?

LITERATURE REVIEW

Together with my research colleague, I have in line with Andersson et al. (2019) chosen to call the process aiming to create sustainable changes in teaching practices *teachers' collaborative learning*. In other texts and studies other names are used as synonyms or as concepts closely related to what we mean, one example is *teachers' professional learning communities* (e.g., Olsson, 2019). Teachers' collaborative learning can be described as a process in which teachers work together with a self-identified deficiency in pedagogical practice to create sustainable changes (Andersson et al., 2019; Olsson, 2019). The following quote is the definition of collaborative learning used in this paper.

> A group of teachers' jointly and systematically organized work consisting of content-focused, inquiry-based, creative and tentative communicative processes. Where these processes continuously change the work itself and/or the group and/or the individual teachers' professional practice and classroom practice. (Andersson et al., 2019, p. 4)

Collaborative learning is an activity through which teachers together analyze teaching, aiming to develop their teaching skills in a specific area. It is in this paper also seen as a sub-set of teachers' professional development. As such there are some core-criteria to fulfil in order to be successful.

A professional development program needs to have a specific *content focus* (Desimone, 2009). The content focus leads to participants developing a *shared vision* (Sowder, 2007). In this study the content focus is on developing a digital source of challenging tasks. Sowder also means that professional development should *focus on students thinking and learning*. For example, teachers tend to better adapt their teaching towards students' learning needs when they reflect on students' reasoning, compared to when they focus on mathematical content (Sowder, 2007).

Active learning is another criterion for effective professional development (Desimone, 2009). Active learning can be performed in several ways, by participating in discussions or workshops, to observe teacher colleagues and collaboratively analyze, reflect on and improve their teaching practice. Most researchers emphasize that the development of teaching practice needs to be linked to student learning, since the overarching goal most often is to improve the latter (Olsson, 2019).

In the study this paper refers to, extra emphasis is placed on collaboration. In his review of teachers' professional learning communities Olsson (2019) found that not only is collaboration among participating teachers important, but also between participating teachers and the facilitator who often is a researcher. Therefore, teacher-teacher collaboration and teacher-researcher collaboration are both assumed to be important criteria for teachers' collaborative learning.

There are studies showing that teachers need deep mathematical competence to be able to teach mathematically highly able students (e.g., Hoth et al., 2017). On the other hand, there are other studies concluding that teachers' knowledge of students' learning processes is of greater importance than content knowledge (e.g., An, Kulm, & Wu, 2004). Teachers teaching lower grades are aware of their lacking mathematical knowledge and they themselves express teacher collaboration as a solution to be able to meet the learning needs of mathematically highly able students (Mellroth et al., 2019). Teachers' mathematical skills can naturally also be improved after teacher education. For example, teachers who choose, and have the option to continuously participate in professional development

where challenging tasks are included develop both pedagogical and mathematical skills (Chamberlin & Chamberlin, 2010; Mellroth, 2020; Mellroth et al., 2019; Singer, Sheffield, Freiman, & Brandl, 2016).

To meet the learning needs of mathematically highly able students, teachers must be aware of what these students' needs are. Some of these are: (a) Opportunities to learn quickly and less repetition (Mhlolo, 2017). (b) Teacher guidance and less time to solve complex tasks (Nolte & Pamperien, 2017). (c) Guidance to move ahead (Gronostaj, Werner, Bochow, & Vock, 2016). (d) Encouragement to experience failures (Nadjafikhah, Yaftian, & Bakhshalizadeh, 2012).

In the study related to this paper we aim to measure teachers' collaborative learning in a project which aims to develop learning opportunities, through well-developed mathematical tasks, for students with high ability in mathematics. Lesh and Sriraman (2010) have concluded that research in mathematics education need more cumulative research. This study springs from a former school development project (Andersson et al., 2019) and the research related to it (e.g., Harvey & Teledahl, 2019). In line with Harvey and Teledahl we have therefore chosen to study the participating teachers' learning process through the Cultural-Historical Activity Theory (CHAT).

THEORETICAL CONSIDERATIONS

Through CHAT, learning as a human activity is understood in relation to its history, culture and context, thereby the theory takes a social perspective (Engeström, 1999). The activity system is often illustrated as in Figure 1.

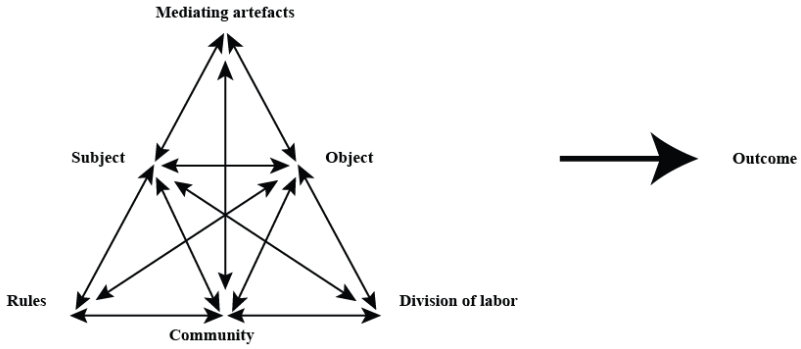

Figure 1 Activity system, illustrated by Engeström (1999).

The theory is briefly presented here, based on the work by Harvey and Teledahl (2019). For deeper explanation I refer to Harvey and Teledahl and to Engeström (1999), the original source of CHAT.

The six nodes in the activity system define the explicit activity system the theory will be used on. The *Object* of the activity is the object of analysis, here the teachers learning about teaching students with high ability in mathematics through challenging tasks. The *Subject* is the participants in the activity, which for this study is the eight teachers who participate in the project. The *Mediating artifacts* are the tools which are used to fulfill the *object*, that is the seminars, workshops, discussions etcetera that the facilitators and participants have chosen and/or developed to fulfil the aim of the project. *Rules* are both norms and rules, explicit and implicit, that the participants in the activity share. They can for example come from traditions of professional development and school culture. The *community* refers to the context the *subject* belongs to. In this study this refers to the group of eight teachers and the

specific school they work at. *Division of labor* describes explicit rules for the subject, for example the number of hours they are given to participate in the project.

THE SCHOOL DEVELOPMENT PROJECT

This study is based on a school development project requested by school leaders in a city in Sweden. The aim of the project is to improve mathematics education in upper secondary (Grades 10-12). In this aim, students with high ability in mathematics are specifically addressed as the only mentioned subgroup of students. The teachers in the project are expected to commit themselves to collaborative learning and the connected research is also expected to investigate and improve collaborative learning as a process to develop sustainable changes in school practice. The project and the connected research are extensions of a former project in elementary school (Grades 1-9) in the same city (Andersson et al., 2019).

The eight participating teachers were the group of teachers in the city who showed most interest in the project when the school leaders launched it. My research colleague and I were initially facilitators of the development project. As facilitators we designed meetings with the participating teachers. In a collaborative learning process, it is emphasized that it is the participants who should identify a problem which they work on together to solve (Olsson, 2019). These teachers expressed that they missed a source of challenging tasks connected to the curriculum. Specifically, such tasks for students with high ability in mathematics were missing. The teachers therefore decided that together they should develop a digital source of challenging tasks.

Aiming to strengthen teachers' knowledge of task construction for students with high ability, the facilitators developed the meetings (90 minutes, every third week in autumn 2019) and choose literature for the teachers to read and discuss (e.g., Sheffield, 2003; Szabo, 2017; Tomlinson, 2016). Together with the teachers the facilitators developed protocols to use when analyzing and developing tasks and to use after a task has been implemented in a class. The questions in the protocols were designed to help the teachers reflect on the activities in relation to the read literature. When this paper was written the implementation phase of the tasks had not yet started.

All meetings with the teachers were audio-recorded, the teacher discussions will be the primary source of data to analyze, the surveys the teachers filled in when analyzing and developing tasks will also be data for analysis.

All participants were informed of the related research when the project was announced. Before data was collected the participants filled in an informed consent form regarding the research study. The teachers were given information that all data would be anonymized in all communication of the project. They were also informed of that they could withdraw from the research part without giving any reason. All participants filled in the form and when writing this paper none has withdrawn.

METHOD

In the analysis two chains of arguments are given, related to this study, for how teachers' collaborative learning can be a process to develop and improve teaching for students with high ability in mathematics. The CHAT theory is used as a guide to connect the argument with the activity – the school development project. To draw conclusions on the outcome of an activity, all six nodes, see Figure 1, in the activity system are important to consider. However, this paper is built on a study that

is in its initial phase and therefore the final outcome is impossible to address. I will focus on drawing arguments for how the *mediating artifacts* positively can interact through the *subject* to enable the *object* to fulfil the aim of the activity.

The *object* of the activity is the object of analysis. In this paper the object consists of the opportunities teachers are given to learn collaboratively about teaching students with high ability in mathematics, through challenging tasks. When the final analysis of the study is done, the object will be the teachers' learning, not the opportunity for them to learn.

The *subject* consists of the participants in the activity, for this paper these are the eight teachers who participate in the project, treated as a group.

In the presented paper the *mediating artifacts* are pivotal in order to fulfil the *object*, thereby the interaction of the mediating artifacts is assumed to create the possibility for the teachers to learn. There may be many mediating artifacts, this paper focuses on the following: (1) Literature on collaborative learning processes, (2) Literature on learning needs of students with high ability in mathematics, and (3) The school development project given as an example study.

The nodes *rules*, *community* and *division of labor*, Figure 1, will only be briefly addressed in the discussion, when it comes to how these three nodes can effect a positive or a negative outcome, based on lessons learned from the foregoing project (Anderson et al., 2019).

ANALYSIS AND PREDICTED RESULTS

The mediating artifacts can be described as a network in which the school development project connects and intertwines all mediating artifacts. As analysis, two chains of argument (A and B) are given in three steps (1, 2 and 3). First (1) specific knowledge of what students with high ability in mathematics need is summarized. Secondly (2), claims are presented for how collaborative learning can be a process to develop teachers' teaching to meet these needs. The claims are given through "**When**…, **then**…." sentences. Thirdly (3), how the school development project is designed to intertwine with the two other mediating artifacts is presented.

Argument chain A

A1) Students with high ability in mathematics need to be given opportunities to learn at a faster speed than most other students (Nolte & Pamperien, 2017, Mhlolo, 2017) and therefore need guidance to move ahead (Gronostaj et al., 2016).

$A2_1$) Drawing on Desimone (2009) and Sowder (2007), collaborative learning can be a promising way to develop teaching skills for including fast learners in teaching. **When** collaborative learning has a specific content focus on how to differentiate instructions related to students' differences in learning ability (e.g., Tomlinson, 2016), **then** the participants will most likely develop a shared vision of how to provide learning opportunities for students with high ability.

$A2_2$) In addition, **when** teachers' collaborative learning focuses on students thinking and learning, for example reflecting on how students with high ability in mathematics reason, **then** (in line with Sowder, 2007) teachers may also adapt their teaching towards such students' learning needs.

A3) The facilitators of the project have given the participants seminars, literature to read (e.g., Sheffield, 2003), and organized discussions on teaching students with high ability in mathematics. In

the discussions the participants are encouraged to give an example of a student who fits with the description of a highly able student. Through these discussions and through sharing, good examples of how different learning situations for such students can be organized are given. One predicted outcome is that the participants will create a shared vision of how, in the regular classroom, to support students with high ability in mathematics to learn at their own speed.

Argument chain B

B1) Students with high ability in mathematics need to be encouraged to experience failures (Nadjafikhah et al., 2012). Therefore, they need to be given mathematical tasks that are challenging for them. Consequently, teachers need to be able to recognize and/or develop tasks that are challenging for students with high ability in mathematics.

$B2_1$) **When** teachers collectively participate in active learning to develop challenging tasks for students with high ability in mathematics, **then** the process for collaborative learning fulfils some criteria that should lead to effective professional development (see Desimone, 2009).

$B2_2$) **When** teachers collaborate on the connection between practice and students' learning, through challenging tasks, with other teachers and preferably with a researcher as facilitator, **then** the collaborative learning process is enriched (see Olsson, 2019; Singer et al., 2016).

B3) In the project the facilitators and the participants together have developed an analysis protocol, partly based on criteria of rich learning tasks (Sheffield, 2003) to analyze and develop tasks. The developed tasks will be implemented in the classroom and further developed. One aim of the project is to develop tasks that are challenging for the highly able students, meaning that students with high ability will also have to struggle with these and therefore risk failure. Through this procedure the participants share experiences of developing and implementing tasks, and together they reflect on how students with high ability in mathematics learn mathematics from these tasks. According to Olsson (2019) and Singer et al. (2016) this process follows a key-procedure to improve teaching to improve students learning.

DISCUSSION

It is a complex task for a teacher in a regular classroom to organize teaching that is inclusive for highly able students, it is a skill teachers need to develop. As the two chains of argument have shown, teachers' collaborative learning can be a promising process for teachers to develop such teaching. When the teachers collaboratively analyze and reflect on mathematical tasks based on criteria given for challenging tasks (Sheffield, 2003), they simultaneously develop the tasks aiming to give learning opportunities to students with high ability. It can be assumed that when they engage in this active learning with a specific content focus, they develop a shared vision of how to teach inclusively for all students, as well as those who are highly able.

The given arguments address two learning needs for students with high ability in mathematics; there are other learning needs not mentioned in this paper, for example the need to sometimes learn together with likeminded peers (Nolte & Pamperien, 2017). However, through collaborative learning it is possible that teachers can develop teaching to also meet other learning needs among students. To give validity, arguments on how collaborative learning can support the development of teaching skills can be given in a similar way as in this paper before starting the process.

Through the CHAT theory the opportunities for teachers to learn about teaching mathematically highly able students are analyzed. Three nodes, *community*, *rules*, and *division of labor* are not included in the analysis, although they are important for the outcome. Together these three nodes can be summarized as democratic values affecting the outcome. It is of importance that all participants feel they can express themselves and that their voice counts. Explicit and implicit rules among the participants can affect the group dynamic, which in turn can affect the communication positively or negatively, such rules should therefore be analyzed as a part of the CHAT theory. The division of labor is related to the hierarchy within the group and outside the group, external factors like organizational support to provide meetings between the participants belong to this node. For example, when organized time for collaboration is given, teachers become more positive towards opportunities to plan and reflect on teaching together with their colleagues (Nordgren, Kristiansson, Liljekvist, & Bergh, 2019). When teachers are given opportunities to collaborate it benefits students' achievement and the quality of this collaboration is strengthened when practice and research are combined (Timperley, 2011). However, it is crucial that the environment between researchers and participating teachers is open-minded and built on trust, and that input from participants and researchers has equal worth (Olin et al., 2016).

Previous studies (Borko, 2004; Chamberline & Chamberline, 2010; Mellroth et al, 2019; Mellroth, 2020) where teacher collaboration has been a core element have shown that when teachers develop challenging tasks for students with high ability they gain knowledge of teaching these students. This paper contributes by giving arguments for why teachers' collaborative learning can be the core-criterion for developing teaching practice in the regular classroom to include students with high ability in mathematics in learning.

Acknowledgements

Thanks to my co-researcher in this study, Andreas Bergwall, and to Attila Szabo who have given constructive comments on this text. The project is funded by Örebro kommun, Sweden.

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ISBN 978-91-7867-161-8 (pdf)

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