Developing a collaboration tool to give every student a voice in a classroom discussion

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In this paper we outline suggestions for a new prototype tool that is currently under development. This new tool will combine a powerful mathematic software and a student response system, which allows teachers to create a classroom culture where students can give explanations. It will shorten the time for collecting students' responses and offers possibilities to work with these responses afterwards. By conducting semi-structured interviews with teachers highly knowledgeable in using technology, we found out that they need new features for formative assessment to foster classroom discussions. These include monitoring and collecting students' work in a convenient way and using students' responses in varying follow-up activities in a classroom. With this tool, teachers could have the advantage of encouraging students to explain their thinking by giving each student a voice during classroom discussions by letting them write down their thoughts and sharing them easily in class.

Keywords: classroom communication, formative assessment, student response systems, student participation.

Introduction

Our recent project is about the process of developing a new online collaboration tool, in which we want to use a powerful mathematics software and to further develop an existing online tool into a connected classroom technology application by adding new features and functionalities. "Connected classroom technology refers to a networked system of personal computers or handheld devices specifically designed to be used in a classroom for interactive teaching and learning" (Irving, 2006, p. 16). In literature, similar names appear for connected classroom technology (CCT), such as student response systems (SRS) or classroom response systems (CRS). Their common features are that they facilitate the communication between teachers and students, they display student responses in real time, and allow rapid aggregation of student work by teachers (Fies & Marshall, 2006; Irving, 2006; McLoone, Kelly, Brennan, & NiShe, 2017; Shirley, Irving, Sanalan, Pape, & Owens, 2011). According to Wright, Clark, and Tiplady (2018) connected classroom technologies offer a broad range of innovative features, which are summarized in various researches and also explored in a variety of approaches within a project. One great potential of connected classroom technologies is that they offer immediate information about students' progress to teachers as they could monitor their students' work real-time (Irving, 2006; Shirley et al., 2011; Wright et al., 2018). Moreover, connected classroom technologies enable most of the students to contribute to activities and taking a more active part in a classroom discussion (Roschelle & Pea, 2002; Shirley et al., 2011; Wright et al., 2018).

The used technology in our case is GeoGebra, a tool on teachers' and students' devices that are connected online and can be used for teacher and student interaction. We want to develop a new tool, called GeoGebra Classroom, that offers new opportunities for mathematics teaching to support teachers as well as assists students' learning. Furthermore, we want to explore how this tool may contribute to mathematics education and how teachers are using it for formative assessment. “Formative assessment refers to frequent, interactive assessments of student progress and understanding. Teachers are then able to adjust teaching approaches to better meet identified learning needs” (OECD, 2005, p. 13).

At the beginning of the project we wanted to find out whether or not teachers are satisfied with existing collaboration tools, why they are using a specific tool or feature, and if they need any additional features or functionalities for their classroom teaching with an online tool. Therefore, we conducted interviews with teachers where we focused on the research question “What do teachers need from an online collaboration tool to support their mathematics classroom teaching?”.

Methods

To approach this research question, we conducted semi-structured interviews with six experts, three men and three women, who are highly knowledgeable in using technology. We chose four experts from Europe and two from North America as they could give us broad international insights for our research. They are experienced with using online tools in their teaching because they work with several online tools in their mathematics teaching regularly. One expert works as a mathematics online teacher, where the use of online tools is indispensable. The other experts work in secondary schools or in teacher education. The interview guide focused on experts’ opinion and experiences on the following topics: uses of technology and different tools in mathematics teaching; features and functionalities of online (collaboration) tools; expectations, needs, and requests for new collaboration tools or features.

The interviews with two experts were conducted face to face and with four experts via an online video conferencing platform where audio and screen recording was used to collect the data. The duration of the interviews was between 30 and 60 minutes. During the interviews experts also presented examples how they are using different online tools in their teaching or in their research and where and for which purpose they need additional features. One interview was conducted in German and all the other interviews were conducted in English. All interviews were transcribed and analyzed by using qualitative data analysis based on qualitative content analysis (Mayring, 2014, 2015, 2020). According to Mayring (2020) the qualitative content analysis' approach is category-based, where the categories are referring to aspects within the text and the process is research question oriented. Characteristically, this analysis is systematic and follows a strict rule management, where the process is described step-by-step.

For our analysis, we chose the “Inductive Category Formation”, which is one specific technique of the qualitative content analysis, described by Mayring (2014, 2015). By using this technique, our categories derived directly from the material in a generalization process. First, we defined the selection criterion, where we focused only on those phrases or sentences of the interviews that answer the research question. When working through the transcripts line by line, the categories were formed, either by adding the phrases or sentences to an existing category if it fits, or by forming new categories. After the analysis of the first interview, a revision of the category system and the level of abstraction was done and then the other interviews were analyzed the same way. The following paragraph highlights results and main categories that extracted from the data.

Interview Findings and Categories

Based on the interviews, we found out that the experts were using several online tools in their mathematics teaching and each of those tools for a specific purpose. Nevertheless, they wanted new features or functionalities for existing tools or newly designed tools for formative assessment that offer them additional ways of teaching. They came up with various ideas how they might want to use specific new features aligned with their current teaching methods. The findings show that teachers request features that allow and support more interaction and communication between teachers and students and among students. They wanted connected technologies to monitor students in real time and to be able to use students' responses in varying follow-up activities. Such a tool should collect the responses in a convenient way on a dashboard where teachers can sort and organize responses so that they can be presented to the whole class during the same lesson. In a follow-up classroom discussion, they may want to compare different responses or highlight individual exemplary responses. Suggestions of the experts were grouped into the three main categories "Collaboration", "Real-Time Monitoring", and "Whole-Class Discussions". The following subsections highlight some of the experts' opinion regarding how they think a new tool can assist students learning and support teachers in creating a classroom culture where students give explanations, and which can be used for an upcoming whole-class discussion.

Collaboration

Teachers wanted students to collaborate and to interact with other students. As one example, one expert told us about her experience in her teaching.

> Expert 1: "I think that learning, probably anything, but specifically math works better socially. So, when you get your kids talking about your own learning, either to me or to each other. I think that is a more natural way of learning. […] So, any kind of tool allows that to happen, I am gonna find the best ways to use it."

Real-Time Monitoring

This expert also told about her experiences with an existing online tool that allowed her to monitor the students' work on her screen. The teacher experienced that every student was participating and working through the activities, when they knew that they were observed. As a result, students actively participated in the conversation afterwards, either by giving their own input or by asking questions.

> Expert 1: "I see them all doing the task. Every single student is participating and mowing through it, and as a result, when it comes have a talk, everybody is participating in the conversation."

The possibility to monitor students' work in real time had also an additional benefit according to two experts. They used this feature in an existing online tool for formative assessment and appreciated the possibility to make students' thinking visible.

> Expert 2: "… make students' thinking visible and use it as a basis for classroom discussion."

Whole-Class Discussions

Some experts also made suggestions on how to use student responses to foster classroom discussions. They wanted to present students' responses, either in written form or submitted in multiple ways -

via pictures, words, symbols, or in some other format such as geometrical constructions or graphing functions and to use them to discuss mathematical issues.

> Expert 3: “I would like to see only three different answers about three different aspects, and I would say, ok there were more different answers, but now we are going to discuss these.”
>
> Expert 4: “If I wanted to show them all I could do that with the screen. So, in some cases if there was a big discussion, I would actually do that. Throw up every answer and we would discuss. But maybe not from the content of the answers, but from the type. Like we would discuss: Ok this answer is not complete, because they only say what they mean, and they never explain why, or something like this. So, I was pointing out to them more how do we work in math class than this is a correct answer.”
>
> Expert 1: “… it facilitates such high participation in such high-level conversation about maths …”

As it can be concluded from the experts’ quotations, students and their work should be in the center of the lessons. Experts want to put student explanations in the focus of classroom discussions and to use a tool to facilitate formative classroom assessment. They need a tool to encourage students to participate in classroom activities, to assist students in explaining their thinking, and to support classroom discussions.

Features for GeoGebra Classroom Tool

We took experts opinions into consideration when designing the new features for the GeoGebra Classroom tool that can be used with the GeoGebra resources. Even though we interviewed only a few experts and cannot draw any general conclusions, the results are good indications for the start of the development of the prototype. The GeoGebra resources can be used for all levels of education and thereby the GeoGebra platform offers a broad range of applications in a classroom setting. There are already more than one million free activities available on the GeoGebra website (GeoGebra, 2020).

Figure 1 and Figure 2 show two examples of existing characteristic GeoGebra resources. The first worksheet includes a prepared applet, where students can move the slider and drag the points to explore a mathematical concept. Below the students are advised to answer the two open questions. The second worksheet includes an empty applet, where students are advised to construct an equilateral triangle and then answer the multiple-choice question. Every worksheet can be created or edited to provide the powerful applet along with other question elements. This way students have mathematical tasks, explorations or constructions and response elements at one page close to one another.

The following subsections describe how a new and improved system on the GeoGebra platform, the GeoGebra Classroom, put students’ responses in the focus, give every student a voice, and how it could support interaction in mathematics classrooms. Furthermore, we present possible scenarios how teachers could apply the GeoGebra Classroom tool for their classroom teaching.

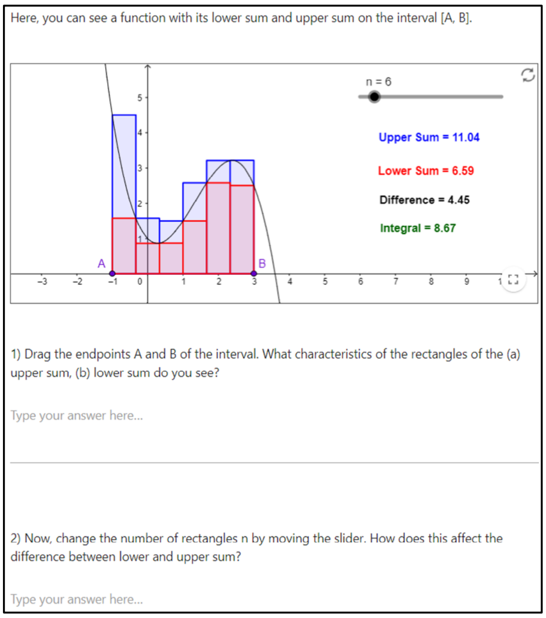


Figure 1: Worksheet 1[8]

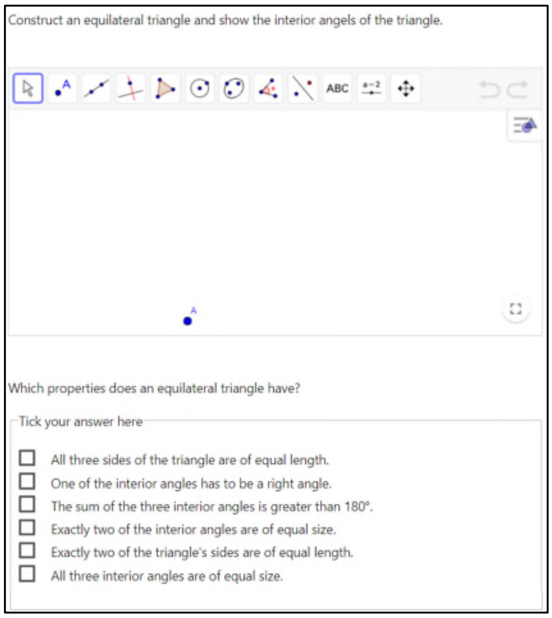
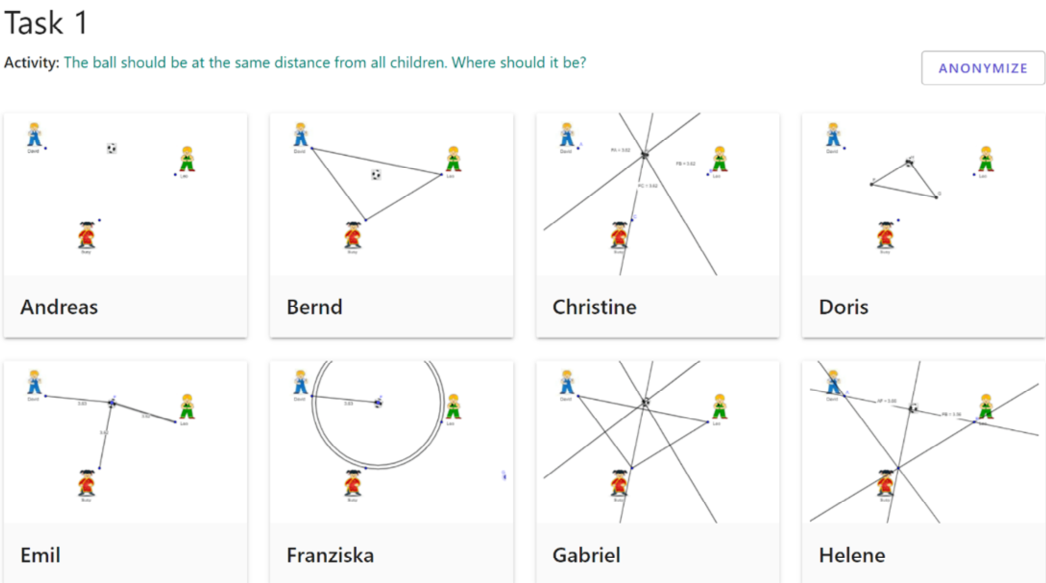


Figure 2: Worksheet 2[9]

Encouraging Students to Think (and Talk)

First, teachers hand out a sharing code for a GeoGebra resource that allows each student to enter a joint workspace online. Such an activity could consist of an interactive GeoGebra applet, where students can drag points, move sliders, change data, or construct objects in one of the available views, accompanied with question elements. Students could work on their own or in pairs sharing one device, which could be their phone, tablet, or laptop. No matter whether they work on their own or in pairs, each student is advised to think about the task and do the manipulations or constructions in the applet.



8 GeoGebra. https://www.geogebra.org/m/wcbcr49k, last visited Apr. 12, 2020.

9 GeoGebra. https://www.geogebra.org/m/ec9ysby5, last visited Apr. 12, 2020.

Figure 3: Teacher dashboard with student applets

The new features allow teachers to see at a glance and in real time all work done by their students. Teachers could observe all the manipulations that students are performing with an interactive applet (e.g. geometric constructions or function graphing, see Figure 3) while the students are working with it. When students are working together, they should talk with each other about their observations, manipulations or constructions.

Encouraging Students to Explain or Reason

Equally important is the fact that teachers can see all explanations or reasonings of students as written responses on a teacher dashboard. On the worksheet the students are advised to write down a response or explanation in the provided input box. This way, teachers have an overview of all the responses and can read through them without losing time by collecting them and can easily compare all students' responses in a quick and convenient way. Each student's response appears one after the other, and students know that their response is noticed by the teacher (see Figure 4).

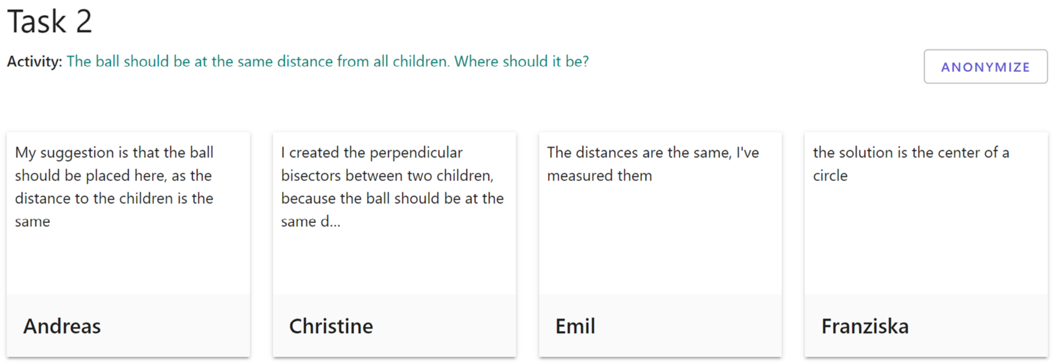


Figure 4: Teacher dashboard showing student explanations

According to one experts' experience, every student in the class is participating, when they know that they are observed. This experience coincides with a study result, where different student response systems were used in a classroom. "The students' observed behaviors indicated overall engagement during the learning process as they used the SRS" (Fuller & Dawson, 2017, p. 383). The participation included answering the teachers' question by using technology, responding to the collected data, and discussing questions with other students (Fuller & Dawson, 2017).

One big advantage and improvement of the question element will be the possibility to write mathematical formulas or expressions by using an equation editor. Students will then be able to submit a written text together with different mathematical symbols, write fractions, or add Greek letters in one input field. In this way students will be able to explain their mathematical observations not only in words, but also by using the correct mathematical language.

Encouraging Students to Discuss Mathematical Explanations

Teachers can drag and drop responses to organize and sort them to address a specific issue. When it comes to a classroom discussion the teacher can pick any response, either one or more, and present them to the other students in the classroom. If needed, the teacher can also show all of them and let the students read through them quickly. This way, each single response will be read, and each student could give an input for the discussion by submitting the response. By doing that, the teacher and the students can analyze the type of responses or mathematical meaning in a classroom discussion. Students will then be advised to take part of the classroom discussion as well. As a result, by using this new tool, the teachers can assist students in developing their skills in writing an explanation or in explaining their reasoning.

Another benefit of using such a system is that teachers can anonymize the responses. Therefore, each student can participate actively, and no one needs to worry that their name will be shown during the discussion. In addition, teachers can select responses randomly without knowing which student wrote it. The anonymous feature creates a safe environment in a classroom where all students' responses are taken seriously without fear of embarrassment.

Further Research

The continuation of this project will be based on a prototype system of the GeoGebra Classroom tool, including the features described above, where we will conduct further research focusing on the use of the new features in a classroom setting and analyzing how this tool affects mathematics teaching. We are particularly interested in how teachers will use this new tool and how they and subsequently their students will benefit from using it in the classroom. Furthermore, we will test it for several reasons as it should be easy and pleasant to use for teachers and as well for students. Moreover, we will create or adapt tasks, that have an additional benefit for students when they are working with this prototype. Finally, we want to find out how and to what extent the prototype, and subsequently the tool, can support teachers and how it can offer them new opportunities in teaching.

The contribution of this paper is to point out to teachers and other researchers that this new designed tool could have advantages in various fields. As it will allow a variety of possible applications in teaching methods, teachers should adapt it for their teaching needs in classroom. It could help researchers who are investigating students' use of language in mathematics classroom as they could easily collect students' responses and focus on those for an upcoming discussion. It could be useful for researchers who are working on orchestrating whole-class discussions by using online resources (e.g. Fahlgren & Brunström, in press). Moreover, it could be useful for new types of activities, such as the MERLO items, which are including interactive applets and explanation tasks for students (e.g. Arzarello et al., 2015). Additionally, it could also assist teachers, who are teaching online regularly or assist teachers in remote or distance learning, as those teachers could then see the work of their students in real time, although they cannot really see the students.

In addition, several follow-up questions arise regarding the content of teacher trainings, where teachers can discuss how to use such a new tool in order to focus on students' responses and to foster interaction in the classroom. This includes strategies on how to choose or design appropriate tasks, how to efficiently observe student responses, how to decide which responses to pick and how to orchestrate classroom discussions.

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