Opportunities and challenges that silent video tasks bring to the mathematics classroom

Bjarnheiður Kristinsdóttir

Abstract This chapter provides readers with a new perspective on how short, animated video clips can be used in the mathematics classroom to elicit, attend to, discuss, interpret, and respond to student thinking. It reports on findings from a case study conducted over one school term in collaboration with three Icelandic upper secondary school teachers who implemented *silent video tasks* in their classrooms and took active part in developing the tasks' instructional sequence. By viewing the tasks' potential along the five dimensions of powerful mathematics classrooms defined by the TRU framework (Teaching for Robust Understanding) and comparing them with data from classroom observations and teacher interviews, I aimed to identify opportunities and challenges that silent video tasks bring to the mathematics classroom. Special emphasis was put on the formative assessment dimension. This chapter contributes to the research community's current knowledge of the role that short, animated videos can play in teachers' formative assessment practices. Results of this study confirm previous research indicating that students' responses to silent video tasks can give teachers valuable insights into students' mathematical understanding and enable teachers to refer to students' ideas in a new way in classroom discussion. The biggest challenge created by the silent video tasks was the delicate task of orchestrating meaningful classroom discussions based on students' task responses.

Keywords Task design • Silent video tasks • Teaching for robust understanding • Formative assessment • Video narration technology • Teacher practices • Technology-mediated practices

---

B. Kristinsdóttir (✉)
School of Education, University of Iceland, Reykjavík, Iceland
e-mail: bjarnheidur@gmail.com

Introduction

The use of short films for the teaching and learning of mathematics has become more common as flipped classroom approaches and resource collections such as Khan Academy gain more popularity (Cargile & Harkness, 2015). Instructional videos used in mathematics classes are usually created by teachers, but as access to technology for video narration and creation becomes more widespread, the roles of teachers and students can change. For example, students can create a narrative to accompany a silent animated video (Kristinsdóttir, Hreinsdóttir, Lavicza, & Wolff, 2020) or become video creators (Oechsler & Borba, 2020) and thus take on an active role in their learning.

This chapter describes and analyses teachers' implementation of silent video tasks (SVTs), where students are asked to add their own narrative to a silent animated mathematics video, share it with their teacher and peers, and reflect on each other's task responses in a whole class discussion. It draws on data from the final phase of a multi-phased design-based doctoral study that aimed to design, define, develop, and implement silent video tasks in collaboration with Icelandic upper secondary school teachers. From here onwards this particular phase will be referred to as a case study. Previous research indicated that SVTs might give teachers insight into students' current level of understanding and thus be useful for their formative assessment practices (Kristinsdóttir, Hreinsdóttir, & Lavicza, 2020; Kristinsdóttir, Hreinsdóttir, Lavicza, & Wolff, 2020). Therefore, the case study emphasis was on further developing SVTs' instructional sequence to support teachers' technology-mediated formative assessment practices and to get a clearer picture of how and why teachers could or would use SVTs in their classrooms as part of formative assessment.

The chapter focuses on the teachers' role in the integration of video narration technology for the purpose of assessment in mathematics. Such technology is an important part of students' social media culture but has hitherto rarely been utilised for mathematics teaching and learning. The chapter aims to contribute to the mathematics education research community's current knowledge (e.g. Bellman, Foshay, & Gremillion, 2014; Venturini, 2015; Olsher, Yerushalmy, & Chazan, 2016; Venturini & Sinclair, 2017; Aldon & Panero, 2020) related to the use of technology in assessment, with a specific focus on video narration. The next section gives a short historical overview of the ways in which silent video clips have been used for mathematics teaching and learning in the past. It will be followed by a description of the research context and an introduction to the frameworks used to analyse data.

Background: Silent Video Clips for Mathematics Teaching and Learning

Silent videos include no text, music, voice-over, recordings of classroom settings, or human beings. They solely include dynamic representations of mathematical objects; illustrations that change in time but never fail to stay intact with the definition and properties of the object. For example, a silent video could show a triangle inscribed in a circle such that one of its sides is equal to the circle diameter. As the vertex opposite to the diameter is moved along the circle

circumference, its angle remains 90°. For a student who is unfamiliar with Thales' theorem, this might be surprising, evoke curiosity and be worth seeking explanation for.
Despite them not being interactive, in a way, animated silent films showing mathematics dynamically can be seen as a predecessor of digital geometry software (DGS), which came about in the 1980s. The use of silent video clips for mathematics teaching and learning dates back to 1910, when the German mathematics teacher Ludwig Münch (1852-1922) produced and screened thirty short, animated films about geometry and astronomy for his students. Twenty of Münch's films are known to exist in archives, on topics such as the Apollonius circle, but they are not accessible to the general public (Kitz, 2013).

Better known are the animated geometry films made by the Swiss teacher Jean Louis Nicolet in the 1930s, as they were widely introduced to teachers by the mathematics educator Caleb Gattegno in the 1950s (Tahta, 1981). Later, Gattegno also introduced films for university teaching made by the UK teacher Trevor Fletcher between 1952-1979 (Tahta & Fletscher, 2004). Gattegno, who was a founding member of the Association of Teachers of Mathematics (ATM), reconstructed the Nicolet films in colour with computer animation and underlined that they were not merely illustrations but tools that teachers could use in many ways both in terms of explanations and follow-up work to promote mathematics learning in the classroom (Gattegno, 2007; Tahta, 1981). A recent example of such work is Sinclair's use of the Nicolet-Gattegno film *Circles in the plane* to invoke gestures with her students as they studied the mathematical concept of circle by watching the film a few times in a row, each time with a new task to imitate the video: first by talking, then by moving their hands, and finally by drawing (Sinclair, 2016).

Silent videos differ from the majority of mathematics videos that can be found via YouTube, Vimeo, and similar sources, in that they are not directly instructional. Rather, they are intended to be thought-provoking. Silent videos used in SVTs are usually less than two minutes in length and thus shorter than the Münch, Nicolet, and Fletcher films. Despite differences in length, all these films have in common that they do not pose a mathematical problem to be solved. Rather, they invite viewers to wonder, experience dynamically changing mathematical objects and think about characteristics of mathematical phenomena shown such that they might discover something new or consolidate previous thoughts about the mathematics shown in the video.

Silent Video Tasks

Silent video tasks (SVTs) involve the screening of a short (less than 2 minutes long), silent, animated video clip on a previously studied mathematical topic. The video is designed to invite description, explanation, and/or narrative with possibilities to generalise. Working in pairs, students are invited to prepare and record their voice-over to the video clip. Students' responses to the task get listened to and discussed in a whole class discussion lead by the teacher. During the discussion, teachers can ask and prompt students with the aim to approach common understanding of mathematical concepts and properties. A vignette might help readers visualise the task implementation:

> We enter Anna's classroom. She shows a one-minute video clip (see https://youtu.be/8cLrbJM4F-I) to her 16-year-old students in a remedial class. It displays a topic that they have been working on for the past two weeks: Different zones of the Cartesian coordinate system (e.g. x > 0) are highlighted successively in distinct colours, and four points appear one after the other. As the class watches the video, a student can be overheard commenting that there is no sound. Anna acknowledges this observation and explains to students that it will be their task to add the narration to the video.
> "What are we supposed to talk about?", one student asks, and Anna replies, "Whatever comes to your mind. Imagine a blind person visiting, how would you narrate, describe or explain to them what is going on in the video?". She assigns students randomly into groups of two and gives them twenty minutes to watch the video as often as they want to whilst they work on their recording. Some students try to fish for what Anna "wants them to say" (without success), but others start recording after a short dialogue. Gathered back in the classroom, Anna plays one student response after the other, stopping the playback every now and then to ask for clarification or point students' attention to something specific: "Did you understand that? What do you think they wanted to say here?" and "Can you explain what you mean by…?"

Icelandic Context

Throughout the research project, I worked with upper secondary school teachers in Iceland to develop the instructional sequence of SVTs and determine their value for teaching and learning in the mathematics classroom. There are 38 upper secondary schools in Iceland, out of which 30 offer lines of study that prepare students for further studies in STEM (science, technology, engineering, mathematics) subjects. The majority of upper secondary schools are state run and those privately owned also receive state support. Until 2015, most Icelandic upper secondary school programs were planned for four years, but now they are planned for three years, during which learners are generally 17-19 years old. Some vocational programs require longer periods of study.

By adding courses to their studies, students in vocational programs have the possibility to complete the matriculation examination in preparation for entering higher education. Although not compulsory, emphasis is placed on providing everyone the opportunity for upper secondary education, irrespective of their results at the end of compulsory schooling (primary and lower secondary education are compulsory). All three school levels, pre-primary, compulsory and upper secondary, are built on the same values as stated in the national curriculum for each level —values such as respect and care for others, tolerance, and responsibility.

Teaching methods in Icelandic upper secondary mathematics lessons are mainly teacher centred (Sigurgeirsson, Eiríksdóttir, & Jóhannesson, 2018) and although some schools use DGS, often it is the teacher who uses the DGS for demonstration purposes rather than the learners using it for discovery (Jónsdóttir, Briem, Hreinsdóttir, Þórarinsson, Magnússon, & Möller, 2014). Formative assessment and group discussions are rarely practiced in Icelandic upper secondary school mathematics lessons (Jónsdóttir et al., 2014).

In accordance with the Icelandic upper secondary school main curriculum from 2011, mathematics teachers suggest course descriptions to the Icelandic Ministry of Education Science and Culture, which checks them for acceptance. From 2011 onward, the course descriptions are expected to include course objectives and competencies that learners are expected to achieve. At larger upper secondary schools where the same course is taught to many groups of learners (e.g. five groups of 30 learners each), each group having one teacher, the teachers collaborate and usually attempt to follow the same course schedule during each semester. Despite the 2011 National Curriculum Guide's emphasis on competencies, an 'undercover' mathematics course schedule with 'lists of things to cover' exists at the majority of upper secondary schools in Iceland. The same phenomenon was observed after a National Curriculum change in 1999 (Harðarson, 2010).

Teaching for Robust Understanding in Mathematics

We can surely agree that there is no prescribed best way to teach. By analysing mathematically powerful classrooms (classroom environments that support students' mathematical learning) of various kinds with teachers applying a spectrum of different teaching methods, Schoenfeld and his colleagues attempted to distil the characteristics of these classrooms into a small number of dimensions that teachers might be guided towards paying attention to. Not to claim that one teaching method was best, but to identify what was important to be aware of. Out of this work came five dimensions that constitute the TRU framework (Teaching for Robust Understanding). They are: i) *Mathematics:* the richness of the mathematical content, ii) *Cognitive Demand:* the opportunity for students to engage in productive struggle, iii) *Equitable Access to Content:* that all students are involved in meaningful ways, iv) *Agency, Ownership, and Identity:* opportunities for students to develop a sense of agency, make mathematics their own, and to develop productive mathematical identities as thinkers and learners, and v) *Formative Assessment:* the degree to which student ideas are made public and responded to in productive ways (Schoenfeld, 2018). Of course such distillation is problematic in the sense that it puts more emphasis on some critical aspects of the teaching practice over others. Intended to help teachers create classrooms from which students emerge as "knowledgeable, flexible, and resourceful thinkers and problem solvers" (Schoenfeld, 2018, p. 494), the TRU framework, however, does not prescribe any specific practices. It only suggests that teachers become aware of and pay attention to ways (and there are many such ways possible) in which they can improve their current practice along the five TRU framework dimensions.

Since the TRU framework is mostly used for teachers' professional development, it was not obvious that it could be useful for the study presented in this chapter. The idea to identify whether silent video tasks offer opportunities to teachers along the dimensions of the TRU framework came up after the data was collected, in the process of analysing it. This was due to the TRU frameworks' emphasis on conversations between teachers and students and ongoing reflection, i.e. building up awareness of and learning from experience. The intentions of the tasks might align well with the TRU frameworks' dimensions, but theory and practice must grow together. Thus, data on teachers' experiences with using silent video tasks was analysed through the lens of the TRU framework with the aim to identify potential challenges. Such challenges are often connected to tensions that arise in teacher practice when social or sociomathematical norms (in the sense of Yackel & Cobb, 1996) in the classroom are violated. Regarding the fifth dimension of the TRU framework, I will connect to key strategies for formative assessment practices by Wiliam and Thompson (2008) and a list of socio-technical approaches to raising achievement in mathematics education as presented by Wright, Clark, & Tiplady (2018).

Formative Assessment

Malcolm Swan argued that "technology usage must move away from merely rehearsing procedural skills (albeit with feedback) toward a usage that mirrors the outside world; it must become a tool that changes the way we think and reason" (2017, p. 31). After all, mathematics is about generalisations, and what varies or remains invariant. By emphasising that, we might improve student learning of mathematics. Previous research indicates that SVTs might fit the description of being a tool that could be utilized to decide about next steps in instruction (Kristinsdóttir, Hreinsdóttir, & Lavicza, 2020), as mentioned in Wiliam's (2011) definition of formative assessment:

> *An assessment functions formatively to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have made in the absence of that evidence. (p. 43).*

For practice, Wiliam and Thompson (2008) further identified the following five key strategies for formative assessment: 1) Clarifying and sharing learning intentions and criteria for success, 2) Engineering effective classroom discussions and learning tasks that elicit evidence of student understanding, 3) Providing feedback that moves learners forward, 4) Activating students as instructional resources for one another, and 5) Activating students as owners of their learning.

Our focus will be set on ways in which technology can be used by teachers for formative assessment practices. In Table 1, I refer to Wright, Clark, and Tiplady (2018, p. 219) who defined six technology-based formative assessment strategies that have the potential to support teaching and learning (see Table 1). Previous results indicated that SVTs addressed all but one of the potentials listed in Table 1, because feedback was not immediate but took place later in a follow-up lesson (Kristinsdóttir, Hreinsdóttir, & Lavicza, 2020). However, as will be reported in more detail in the findings of this chapter, working with teachers who had experience with using formative assessment (referred to as FA hereafter), they emphasised the importance of immediate feedback and changed the SVTs instructional sequence such that discussion based on students' responses would take place immediately after students handed in their responses.

Table 1

Status of ways in which silent video tasks addressed the potentials that technology-based formative assessment strategies might have to support teaching and learning, as listed by Wright, Clark, and Tiplady (2018, p. 219), before the case study was conducted.

Technology-based formative assessment strategies that	**Ways in which silent video tasks addressed these potentials before the case study was conducted**

might support teaching and learning	
Provide immediate feedback	Currently not addressed. Feedback to students is given in a follow-up lesson 1-3 days after students work on the silent video task.
Encourage discussion and developing cooperation	On the basis of some selected or voluntarily played task responses, students are encouraged to discuss and reflect on the ways in which they understand the mathematical concepts that are the topic of the silent video.
Provide an objective and meaningful way to represent problems and misunderstandings	Possible misunderstandings uncovered in student responses can be directly referred to and discussed as useful steps on students' path toward understanding.
Provide opportunities for using preferred strategies in new ways	Teachers who want to build a culture of discussing and collaborating in their classroom surely do not only want students to express their mathematical thoughts in writing. SVTs offer a way to ask for an audio response to a task, thus bringing students' thoughts and ideas to the forefront of the discussion.
Help raise issues that were previously implicit and not transparent for teachers	For example, if students who normally do not speak up in class ('live' format) take the opportunity to speak up via the voice-over (recorded format), there might be a problem of distrust (students not considering the classroom as a safe space for discussion) that needs to be addressed.
Provide different feedback outcomes	Feedback is provided to the whole class via discussion. When needed, teachers can prepare and provide individual feedback after the discussion finds place.

The next section will introduce the case study presented in this chapter.

Method

In the following subsections, I will introduce the participants of the study, what data was collected, and how it was analysed. Challenges in data collection and ethical considerations are also discussed.

Participants

As I was interested in further developing SVTs as a tool for FA, I purposefully selected and contacted three schools that were known for emphasis on FA. Two schools in the urban area accepted participation and all teachers who were interested in participating were invited to join. One teacher at Blackbird (school names are pseudonyms), a small, 16-19, urban comprehensive school and two teachers from Mallard, a large, 16-19, urban comprehensive school (see Table 2) took part in the project. Both schools' policies expect students to be "active participants in their studies", Blackbird explicitly states in its school policy that their studies are "characterised by FA"[1], and Mallard emphasises "use of continuous evaluation of students' progress by a variety of assessment methods". It was also considered helpful if teachers at the schools encouraged learners' use of DGS such as GeoGebra and Desmos and had some familiarity with leading group discussions in mathematics lessons.

Andri, Edda, and Orri (teacher names are pseudonyms, see Table 2) who volunteered to participate in the study were all open to trying out new teaching approaches. Orri was relatively new to teaching and saw both challenge and an opportunity for collaboration in the research project. He had some previous experience with using GeoGebra and Desmos activities in his classroom. Andri and Edda had around a decade of experience with using GeoGebra at Mallard. Together, they had participated in various Icelandic, Nordic, Baltic, and European collaboration projects for professional development.

Table 2

Participating teachers in the second implementation phase of the research project and their teaching experience

Teacher pseudonym (gender)	School pseudonym	Use of DGS	Teaching experience
Andri (m)	Mallard High School	GeoGebra	10 years
Edda (f)	Mallard High School	GeoGebra	20 years
Orri (m)	Blackbird High School	Desmos, GeoGebra	2 years

Among other teaching duties during fall 2019, Andri, Edda, and Orri all worked with low-achieving 16-year-old students in slow-paced remedial classes. They explained that these courses' schedules accommodated flexibility and thus suggested them as good situations in which to try out SVTs. All three planned to use 2-3 SVTs over the period of one semester. It turned out that Orri (N=14-16) implemented three SVTs within one term, whereas Andri (N=22) and Edda (N=13) implemented one SVT each. The numbers in brackets denote the number of students, N, who were present in class during task implementation.

As compensation for their participation, I offered the participating teachers support meetings in case they were working on any changes in their practice. Orri accepted the offer and we met six times to discuss ways to build a thinking classroom (e.g., Liljedahl, 2018) at meetings that were recorded but not transcribed or analysed.

Silent Videos used in this Study

At initial meetings with Andri, Edda, and Orri, we discussed teachers' course curricula and brainstormed to identify topics that might be visualised in a silent video. Based on discussion and brainstorming with Andri and Edda, I sketched drafts and discussed ideas of three videos on the topics of coordinate geometry and linear equations. Then, based on feedback from Orri,

[1] For participants anonymity, the corresponding school policy paper, which is presented on their website, cannot be referred to. The quotes given here have been translated from Icelandic to English.

I used GeoGebra and screen recording software to finalize the videos. All three videos show the coordinate system with (0,0) at the centre; the *x*- and *y*-axis tick-marked with numbers. They were designed intentionally to point students' attention to details in the definitions (characteristics) of the mathematical phenomena in focus. The videos were intended for assessment, but they could also be shown at the start of a lesson sequence to collect students' initial ideas about its mathematical topic in a word cloud.

SVT1. The first video (see youtu.be/8cLrbJM4F-I) focuses on properties of the coordinate system: First, zones of the coordinate system appear highlighted in light-blue colour one after the other: $x>0$, $y>0$, $x<0$, and $y<0$. Next, the quartiles appear highlighted one after the other and a point appears in each of them: 1st quartile blue with (4,2), 2nd quartile green with (-3,5), 3rd quartile pink with (-2,-2), and 4th quartile orange with (9,-1).

SVT2. The second video (see youtu.be/-snC4JLe63g) focuses on the slope of a line. Two points marked A and B, with A = (-3, 1) and B = (-1,2), are shown in blue along with a blue line AB from the start of the video. Point A stays put while B (and thus the line along with it) moves following a rectangular shaped path, pausing for a short while along the path at the following points: (-1, 3), (-2, 3), (-3,3), (-4,3), (-5,3), (-5,2), and (-5,1). Thus, the movement of point B pauses when the line has the following sequence of slopes: ½, 1, 2, undefined, -2, -1, -½, 0.

SVT3. The third video (see youtu.be/aBtlIVTcs8M) focuses on the graph of a line as a function of *x*. One after the other, blue points with integer coordinates along the line $y = x$ show up from (-7,-7) to (8,8) before the line through the set of points is drawn in blue. Next, red points on the line $y = 2x + 4$ show up one after the other from (-5,-6) to (2,8) before the line appears drawn in red. Then, all the red and blue points move along their shortest path to the *x*-axis and back to their lines again. This movement of the points toward the *x*-axis and back to their position on the respective lines is repeated once more before the video ends.

These specific SVTs will hereafter be referred to as SVT1, SVT2, and SVT3. The next section will clarify what data was collected within the frame of the presented study.

Collected Data

Data collected included semi-structured interviews with participating teachers, field notes from classroom visits, students' responses to SVTs, and students' feedback. For the purposes of this case study, my focus was mainly on analysing the interviews and field notes. Prior to the study, I had visited Blackbird and Mallard within the framework of teacher conferences. To get to know the participating teachers and their working places better, I visited them in their schools in August 2019. I also visited Edda once and Orri three times to observe lessons that did not include SVTs. Before and after each SVT implementation, I conducted and audio-recorded semi-structured interviews (Brinkmann & Kvale, 2009) with participating teachers: two with Andri and Edda together, one with Andri, one with Edda, and five with Orri (see Figure 1). These interviews included questions regarding teachers' expectations to and experiences with implementing SVTs in their classrooms. All interviews took place either in teachers' classrooms or their schools' meeting rooms. For the purpose of this study, I wrote classroom observation field notes on three visits to Orri’s classroom and one visit to each of Andri and Edda’s classrooms. The reason for why I collected field notes rather than video recordings from classrooms is given in the next section.

Challenges in Data Collection

What goes on in classrooms involves speech, gestures, and mimes, many of which happen simultaneously in different corners of the classroom or school building. Even though these actions might seem obvious to the participants involved, they can be less obvious and require more careful examination for visitors. Therefore, to grasp what goes on in classrooms in practice, researchers normally aim to collect video recordings rather than only classroom observation notes.

At the point of data collection—due to the recent introduction of the General Data Protection Regulation (GDPR)—school leaders in Iceland were increasingly aware of complexities regarding data collection in their teachers’ classrooms. They preferred field notes over video recordings from teachers’ classrooms. To build trust and positive correspondence needed for research that is done in collaboration with teachers, I thus decided to take field notes.

Ethical Considerations

The Icelandic Data Protection Authority was informed about the research project. Teachers signed an informed consent stating their awareness that they could quit participation at any point in time. Principals signed informed consent granting me permission to interview teachers and to visit their classrooms provided that I would not collect identifiable information about students. They trusted me to treat collected data in a respectful manner and anonymize names. Students received written and oral information about the research project and were informed that they could deny participation, meaning that their voice-over recording would only be listened to by their teacher and not the researcher. No student decided to refuse participation.

Research Design and Data Analysis

By working with teachers—asking them to implement SVTs in their classrooms and to reflect on their expectations and experiences—I took a hermeneutic (interpretive) phenomenological stance (van Manen, 2016) towards answering the question of how and why teachers could use SVTs in their mathematics classrooms. I studied teachers’ actions and reasons given for their actions and transferred between participants (see Figure 1) all suggestions related to the development of SVTs instructional sequence. In the busy setting of participating teachers’ own classrooms, I observed their work and interviewed them to hear their personal insight as to whether and how they could use this tool for the teaching and learning of mathematics. Furthermore, I reflected on teachers’ insights in writing directly after our meetings and again as I analysed the transcripts from our interviews. Iterative cycles of writing notes and reflections contributed to our evolving understanding of how SVTs could be used in the mathematics classroom.

In interviews with Orri, I developed a *think-aloud exercise*, asking him to think aloud about how he would implement the SVT next time and why. In the first interview, the purpose of the think-aloud exercise was to hear his ideas and then in later interviews—after each implementation—the purpose was to re-construct his experiences and record his reflection as well as his expectations for the next round of implementation.

It usually requires training to become aware of, remember and reconstruct our own interpretations; what we were thinking or making sense of. Despite having no training, Orri reflected on what he thought about in-the-moment and related it to planned actions for the next implementation. It was a free-flow and in-the-moment exercise, meaning that Orri could revise his own thinking on the go. During the think-aloud exercise I thus normally did not interrupt unless something needed immediate clarification.

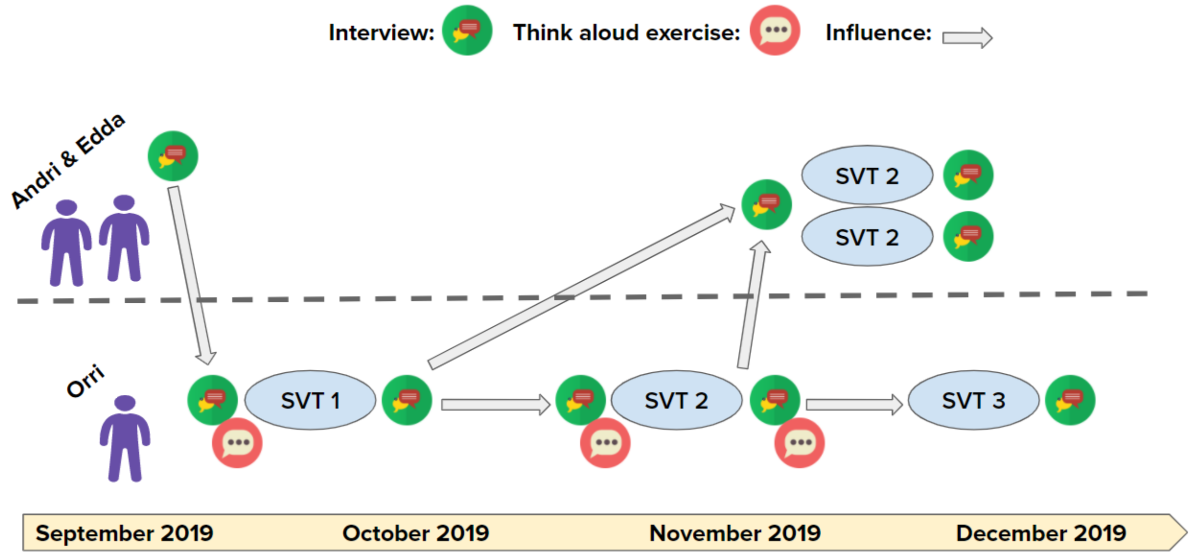

Figure 1 *Relative timing of semi-structured interviews with participating teachers in fall 2019, before and after each silent video task (SVT) implementation. Andri and Edda work closely together at Mallard and thus they were only interviewed separately after the task implementation. Three interviews with Orri at Blackbird included "think-aloud" exercises. When possible, information was transferred by the researcher between teachers, shown by arrows that cross the dotted line between the two schools. The arrows between the three implementations at Blackbird indicate that each implementation informed the next.*

All interviews were transcribed verbatim in Icelandic. When possible, I transcribed directly after the interview took place and thus was able to add some extra notes in parentheses. Analysis started immediately after the first interview and in that first familiarisation phase, I focused on the instructional sequence design and development. After transcribing the last interview, I underwent a second familiarisation phase of the data using open coding in Icelandic on anything that I found interesting in the data. Directly after the second familiarisation phase, I read through the transcripts again, writing detailed notes in English where I summarized and deepened my thoughts. On the basis of the detailed notes, I created a distilled overview of the five interviews with Orri on a large sheet of paper (630x891mm), gaining an overview of how Orri's ideas, experiences, and expectations developed over time.

Regarding opportunities that tasks bring to the mathematics classroom, it comes down to what we consider important. SVTs were developed to be a socio-constructive approach to teaching, a tool that teachers might use to support students in developing their own understanding of mathematics. Previous research has indicated that SVTs occasioned for teachers a fundamental shift in perspective from teacher-centred to student-centred instruction (Kristinsdóttir, Hreinsdóttir, Lavicza, & Wolff, 2020), and although the TRU framework offers no prescription on how to teach, it also includes such a fundamental perspective shift (Schoenfeld, 2018). Furthermore, the TRU framework seemed to provide a language for talking about instruction along dimensions of interest. Therefore, after the phases of familiarization and analysis, I once again read through my detailed notes with questions from the TRU framework (Baldinger, Louie, & the ATSMAP, 2018; Schoenfeld, 2018) in mind. I used these questions (see Figure 2) to determine the opportunities and challenges that SVTs can bring to the mathematics classroom and discussed the findings in a doctoral seminar. The findings are presented in the next section.

Findings

This section starts by introducing teachers' current assessment practices and some ways in which teachers influenced the SVTs instructional sequence. It continues to describe teachers' SVTs implementation before using the TRU framework to identify opportunities and challenges that SVTs bring to the mathematics classroom.

Teachers' Assessment Practices and Influence on SVTs Instructional Sequence

Topic booklets made by Andri and Edda at Mallard and by colleagues of Orri's at Blackbird were the main focus of remedial classes. They were composed of practice problems that were partly exploratory or meant to be worked on in GeoGebra, but mostly they included closed question problems. Work on problems from these booklets counted towards students' final grade. At Mallard, students had access to online self-assessment exercises and completed three exams (each covering part of the material of the course) during the term. A good grade on these three exams made the final exam optional. At Blackbird, assessment was based on students' observed work in class, participation in Desmos classroom activities, handed-in work on problems similar to the booklet problems, and participation in final-week group projects that required knowledge of all topics of the term.

Some emphasis was put on group work at Mallard and Blackbird, but no specific emphasis on developing verbal communication about mathematics. Despite teachers' awareness of the importance of whole class discussions, these were seldom practiced and mostly constrained to teachers asking closed questions, waiting for a response, and either answering the question themselves or evaluating a received response.

All three teachers were familiar with FA practices and what they entailed. This was manifested in the first interview with Andri and Edda as they suggested that feedback via group discussion should take place immediately after students handed in their task responses. Thus, they changed the initially suggested SVT instructional sequence, which was based on previous research (Kristinsdóttir, Hreinsdóttir, Lavicza, & Wolff, 2020) and had placed the group discussion in a follow-up lesson some days after students handed in their task responses, i.e. made space for teachers to prepare themselves by listening to, selecting, and sequencing some task responses to base the discussion. Andri and Edda explained that they expected feedback to be less effective/useful if it was not immediate, similar to what Wright et al. (2018) suggest. Also, Andri and Edda wanted all student responses to be listened to in a random order rather than sequencing some selected responses. Otherwise, students might interpret their actions as if they were judging students' responses "from the worst to the best".

Furthermore, Andri asked if self-assessment and peer-assessment practices could be used such that students would give written feedback to each other's responses. His idea was brought to Orri before the SVT1 implementation. Orri prepared an online reflection sheet for students, where each pair would reflect on three other pairs' responses and at least two pairs would listen to each response. In practice, however, Orri experienced students not taking their role as peer-reviewers seriously. Thus, in the think-aloud exercise before SVT2, he suggested a different approach where the whole group would listen to all task responses in a random order.

Description of Perceived Classroom Norms

Andri and Edda expressed that they aimed to create a safe and constructive working environment for students, especially those in remedial classes. They set a clear frame resulting in a calm and engaged atmosphere. Before the SVT implementation, they wanted to make sure that focus would not move from the mathematics to solving technological issues and therefore prepared by downloading and testing screen recording software (laptops) and sound recording software (smart phones) as well as confirming that the learning management system would suffice to accept students' task responses.

Orri aimed to create a relaxed atmosphere in his classroom. This resulted in a rather loose framing, with students frequently arriving late and leaving the classroom from time to time. He often put in much time to prepare tasks and create feedback for students and repeatedly got disappointed by students not putting effort into their work on prepared tasks and not reading/listening to his feedback notes/videos. Orri expressed explicitly and indirectly that he wanted mathematics to be fun, a trait that he expected would lead to students putting in more effort.

Description of how SVT2 was used by Teachers

Aiming to collect students' initial ideas about the new mathematical topic, Orri showed the video from SVT2 to students at the start of the lesson sequence on the topic of the equation of a line. He asked students to think and write words or concepts that connected to the video and collected these in a word cloud. Orri explained that he never would have thought of some of the words that students wrote (e.g. compass, box, time, and spin) beforehand. Two weeks later, at the end of the lesson sequence, Orri implemented SVT2.

All participating teachers implemented SVT2 in a similar way. At the start of the lesson, they showed the video to the whole class. Its topic (the slope of a line) had been the course focus of the preceding weeks. After explaining that it would be the students' task to add a narrative explanation or description to the video, teachers randomly assigned students into groups of two to work on their voice-over. Despite technical preparations, teachers were observed attending to a few students who had difficulties with either downloading recording software or uploading their voice-over recording.

Some students in each group immediately opened up the link to the video and started to work, but others seemed more confused. This made teachers busy reacting to students who wanted either instructions regarding what to focus on in their response or a confirmation that their contribution was going in a 'right' direction. I had discussed the risk of such *stop-thinking* situations (see Liljedahl, 2018) with teachers during preparation and even though they considered it to be challenging not to answer students' questions, they—upon entering such situations—made clear that it was the students' responsibility to make decisions on what to focus on in their voice-over. Nevertheless, there was apparent tension created by the stop-thinking situations.

Immediately after receiving students' voice-over recordings, the teacher gathered the group together to listen and react to all of them. Similar to what teachers had predicted, students seemed to find it important that their own task response would be played and eager to hear their teacher's and peers' reaction. Still, the teachers' effort to involve students in discussions resulted only in some short reflections and surface-level discussion; no student-to-student debate was observed. The questions used by the teachers to facilitate discussion included asking students to recognize differences and similarities among their responses, and clarifying questions regarding whether and how students understood what was being said. At the end of class, Andri and Edda asked students to answer a questionnaire, on what (if anything) they would have liked to change in their voice-over, if there was anything that made them wonder, and if they would like to add any comments or questions regarding the SVT. Orri, on the other hand, asked students to record a new voice-over, wondering what (if anything) they would change.

In the next section, SVTs intentions will be identified along the five dimensions of the TRU framework. Then, I will present the opportunities and challenges that were identified based on the classroom observation and interview data from teachers' SVT implementations along the dimensions of the TRU framework.

In Theory: Opportunities and Challenges that SVTs might bring

Within the TRU framework, a Conversation Guide (Baldinger, Louie, & ATSMAP, 2018) lists a set of questions intended for teachers' planning and reflection. These questions are organized along the TRU framework's five dimensions (see Figure 2). Based on the intentions behind the way in which SVTs were designed and developed, the questions are answered in Table 3.

The Five Dimensions of Mathematically Powerful Classrooms	
The Mathematics	How do mathematical ideas from this unit/course develop in this lesson/lesson sequence? How can we create more meaningful connections?
Cognitive Demand	What opportunities do students have to make their own sense of mathematical ideas? To work through authentic challenges? How can we create more opportunities?
Equitable Access to Content	Who does and does not participate in the mathematical work of the class, and how? How can we create more opportunities for each student to participate meaningfully?
Agency, Ownership, and Identity	What opportunities do students have to see themselves and each other as powerful mathematical thinkers? How can we create more of these opportunities?
Formative Assessment	What do we know about each student's current mathematical thinking? How can we build on it?

Figure 2
A summary in the form of questions asked within each of five dimensions of mathematically powerful classrooms according to the Teaching for Robust Understanding (TRU) framework (Baldinger, Louie, & ATSMAP, 2018, p. 2, reprinted with permission).

Answering the questions from Figure 2 offered a way to evaluate whether SVTs fulfilled their intended role in theory. Then, to connect with practice, I took a new look at the interview and classroom observation data to perform a top-down analysis, collecting instances that dealt with teacher practice along the five dimensions. This top-down analysis was, then, followed up by a bottom-up analysis of the selected data excerpts with a focus on identifying the opportunities and challenges that teachers encountered during task implementation. Results of that analysis are given in the next section, which is organized according to themes that were identified.

Table 3
When intentions behind the design of silent video tasks are viewed along the dimensions of the TRU framework, some alignment can be seen. Here, questions from Figure 2 are answered based on assumptions about the ways silent video tasks might support teachers in teaching for robust understanding.

TRU Dimension	What silent video tasks are intended for
The Mathematics	By describing, explaining, or narrating the video, students' mathematical ideas are explicitly put into words that get heard and reflected on and discussed by the whole group. Both via recording their voice-over and via participating in the whole group discussions, students might develop their mathematical ideas and create meaningful connections. They might also

	realize whether and in what ways they understand the mathematics shown in the video.
Cognitive Demand	Students might make their own sense of mathematical ideas that arise when watching the silent video and discuss in pairs what to focus on in their voice-over recording. It can be a challenge for students to decide what to focus on.
Equitable Access to Content	Students are offered an untraditional way (recorded verbal communication) to participate in the lesson. It might create opportunities for each and every student to participate meaningfully in the mathematical communication of the class.
Agency, Ownership, and Identity	Students whose response gets listened and reacted to might develop a feeling of belonging and gain a new view on their own articulated ideas as these get discussed by the whole group. As participants (not only listeners) in the discussion, students get an opportunity to see themselves and their peers as mathematical thinkers.
Formative Assessment	From listening, discussing, and re-listening to students' responses to the SVT, teachers gain insight into what students pay attention to when watching the silent video and thus might gain insight into students' current conceptual understanding. Teachers can build on this insight, digging deeper into aspects that seem currently unclear to students. Also, it might be possible to lead students' discussion towards more abstraction or to generalise and to lead the group towards some common understanding of the mathematics shown in the video. Teachers' work with the current group of learners can also be helpful the next time teachers work with learners on the same mathematical ideas.

In Practice: Opportunities and Challenges that SVTs Brought

This subsection is based on excerpts from observation and interview data that were identified to be connected with teacher practice along one or more of the five dimensions. Even though each dimension of the TRU framework involves putting on new glasses that highlight that dimension, some overlap is unavoidable because the categories discussed in each dimension are not completely distinct. Still, usually one dimension was identified to be the most prominent one for each excerpt of data. Labels regarding what dimension each quote or data reference belongs to are not provided here. Rather, the focus is set on introducing the data organized by themes identified regarding opportunities and challenges that SVTs bring to the mathematics classroom. After the listing of themes, these results will be discussed.

Challenge: It is hard to change a prevailing socio-mathematical norm (for example, that there is a single correct answer)

Andri and Edda were surprised by the students' responses that did not mention slope at all and only focused on point coordinates:

Andri: *This was only[2] about the point coordinates.*

Edda: *But they never mention the line slope. And still they say that they would not change their voice-over if they would do a new recording. [referring to students' end-of-class feedback][3]*

They were happy to see that students mastered how to list the point coordinates:

Andri: *what surprised me was that almost all of them put the x-coordinate before the y-coordinate […] in my experience this is endlessly difficult for some students*

Edda: *At least they figured out the point coordinates completely*

Nevertheless, Andri and Edda expressed that they would like their students to gain understanding about linear functions, not only points, even though their coordinates were correctly read. They found it challenging to change students' ideas of what mathematical practice entails in regard to sharing information that one is not yet sure about. If students decided to skip mentioning slope, they suggested it might be a coping strategy due to a socio-mathematical norm that is persistent in the Icelandic school system, which is to assume that mathematics is a practice where only one correct answer exists that matters the most.

Opportunity: Previously inaccessible information revealed by students' task responses

Students' responses made their struggles with the concept of slope graspable and discussable:

Andri: *For example, it becomes painstakingly clear how they have not yet realized, you know[4], [what the concept of] slope [is/means] somehow, the least of them have, at least.*

Andri: *I actually just feel like I always need to teach them this [slope] anew [..,]. You know, I have shown it to them multiple times, you see, but it does not seem like […] it seems like it does not properly arrive.*

Edda: *I noticed that they avoided mentioning [the slope when the line was] horizontal and vertical.*

Edda: *One sees that it is the slope and negative slope that is something that is confusing them […] they do not realize that when the outcome is negative then the slope is negative well they see it approximately but they do not connect it. I find it very interesting*

In the last quote, Edda was referring to students' responses that described the changing slope of the line as ½, 1, 2, 0, 2, 1, ½, and 0 (instead of ½, 1, 2, undefined, -2, -1, -½, and 0). This difficulty hitherto had gone unnoticed but was made visible by students' task response and was received by Edda as valuable information.

---

[2] Words in the transcript are underlined if interviewees put special emphasis on them

[3] In a few cases, for clarification purposes, words within square brackets have been added to the excerpts from interviews.

[4] Commas have been added around common hesitations (such as "you know" or "you see") to make the excerpts from interviews clearer to read.

Similarly, responses to SVT3 revealed a previously unnoticed lack of precision in word use when it came to describing intercepts of a line with the axes of the coordinate system. In retrospect, Orri realized that his own level of precision might be improved:

Orri: *One realizes when one assigns such tasks and does, you know, something, which one finds so obvious that one forgets that it is not obvious at all, you see, one speaks of intercepts over and over again, you know, it is maybe not always obvious that it is often, you know, that there are two intercepts, you see, that one needs to take, you know, that there is not only an intercept that it is a y-intercept and an x-intercept, you see, you know, we find it completely clear […] but to them it is maybe something that one has never properly covered.*

Orri's awareness was thus not only raised regarding students' mathematical discourse, but also his own. Reflecting on how to address students' precision, Orri suggested that he could play a random example task response as an audio file (without viewing the video) and draw on the whiteboard according to what he heard. Then students might realize:

Orri: *Then one would simply say "ok, cuts the x-axis at negative four and the y-axis at negative four ok then it goes through these two points" and they will just say "no we did not mean it in that way" and then I can say "then how can you say it such that it can be understood?".*

This idea was never tested in action because Orri came up with it after the third implementation.

Challenge: It can be tempting to return to teacher-centred transmission of knowledge

Upon noticing students' perception of slope as always being positive, Edda felt it was something under her responsibility to clarify:

Edda: *[…] they have yet to connect that [slope being negative or positive] so it is something one needs to go maybe better through and I did that after showing the last one [student response].*

In other words, although Edda wanted to draw upon students' responses when concluding the discussion, she could not resist reacting with a lecture about slope. Her return to teacher-centred transmission of knowledge might have been influenced by a part-exam which was planned in the upcoming week. Edda expected her students to connect to her clarification because of their SVT participation:

Edda: *So I think it is good to do such tasks [SVTs] and then you can go through the video and explain it better then maybe they will get it better since they have themselves worded it in their own way already and one understands what is wrong and what not so in that way it is very positive so I think it would be exciting to add this task into the [course] curriculum.*

By developing this idea further to make clearer connections to students' responses, maybe what Swan (2006) called a *conceptual reorganisation* might be facilitated when such inconsistencies or obstacles (based on students' ideas) were identified. In that way, students could develop their ideas or build a bridge over the gap. However, as the next theme shows, this was considered by teachers to be a challenging task.

Challenge: It is challenging to lead group discussions based on students' ideas

Leading a group discussion—and especially connecting it to students' words and mathematical ideas—revealed itself to be quite a challenge for teachers:

> *Andri: Ahhh, you know, it is a little scary to do this, you see, but I have in a way done similar things before but still not in this way […] it would be amazing to do this again.*

> *Orri: I think one needs some training in listening well to this, what they are saying and trying to figure out why they are thinking things or I feel that you [the researcher] often hear such things […] things that I had not figured out myself, you see.*

This was not surprising. After all, the orchestration of classroom discussion in the mathematics classroom is a challenging task that requires much practice (Stein & Smith, 2011). Also, the development of awareness of "what students are saying", that Orri mentions above, is important for reflecting in the moment and reflecting on the moment (Pai, 2018, p. 41). Teachers knew that it would be challenging to lead group discussions based on students' work, and they also knew how important it was:

> *Orri: I have to confess that I have not put too much emphasis on that [conversations/discussion] one knows that it is absolutely the thing but somehow one has not dared to dip the toes too much into it.*

After three implementations Orri had a feeling of going in the right direction:

> *Orri: But it was like last time we did the silent video task […] I was showing these and […] felt like it did not go well […] because then I tried, you know, then I was through maybe one half [of the responses] and felt like nobody was following and I did not mention that I just felt they did not bother at all […] but now somehow it was easier it got more fun not fun maybe but interesting when we were all watching together.*

Comparing implementations of SVT2 and SVT3, there was less sense of time pressure in the latter one. Orri was observed gradually activating everyone's attention such that the students' participation in commenting on each other's responses slowly increased. Plenty of time had been devoted to reflecting on each students' response and this seemed to have a positive effect on students' participation. There was also more sense of trust, evidenced by one pair of students showing no sign of embarrassment when their peers' initial response to their voice-over was to start laughing (followed by discussion). They told each other "we did well" as the next response was uploaded to play.

The difference between implementations of SVT2 and SVT3 is described further in the next theme.

Opportunity: SVT practices might support teachers in institutionalising knowledge

Orri mainly posed clarifying questions during his moderation of the SVT2 whole group discussion. Even though students did not participate much, he saw potential for improvement and decided to give it another try in the third SVT implementation. In his reflection, he wondered about ways to enhance students' participation in concluding the discussion and finally, he created a plan during the think-aloud exercise:

Orri: Then toward the end I would like to discuss with them the concepts in general like for instance in this case, you know, slope "What is slope? Can anyone reflect on that?" and yes somehow in this way it would be a summary to tie everything together at the end.

Then, in group discussion based on students' responses to SVT3, Orri carried out his plan by activating students to participate in summarizing the discussion. Furthermore, he connected students' inputs to the topics that the class had been working on in the preceding weeks. Thus, seemingly attempting to *institutionalise* (Brousseau, 1997) knowledge, which is something that Swan (2006) and Aldon (2014) identify as important but often neglected part of teaching practice.

Challenge: It is hard to change prevailing social norms on the motivation role of the final grade

At both Blackbird and Mallard, teachers expressed frustration when students did "not show their true potential" or "not put in enough effort":

Orri: They are not putting in much effort here, […] and they seem not to have bothered to make a new recording.

Edda: I could imagine using such tasks again and then letting it count [toward the final grade] then they might put in more effort.

All three mentioned the motivation role of grades when it came to enhancing effort, i.e. that students generally put more effort into tasks that counted towards a grade. It seemed hard to change this social norm.

Opportunity/Challenge: Providing access to the classroom discussion

Orri: *[…] they might feel uncomfortable that someone is listening to their voice […] I think most of them will be fine […] there just might be some who feel maybe, yeah, uncomfortable.*

Before implementing SVT1, Orri suggested that there might be students who would not feel comfortable with the task. Students can get isolated due to disabilities such as severe anxiety, autism spectrum disorder or language barriers that either cause them to be uncomfortable with group work or having a hard time to communicate. Orri and Andri had one student each on the autism spectrum and Edda had three Icelandic language learners (ILL) in their classes.

Orri described how his student often rejected working on unconventional tasks. Still, both his and Andri's students participated in the SVT. Orri got his student to participate by offering him to work individually and hand in a written script instead of a recording. Andri's student surprised him by participating in group work despite some discomfort:

Andri: *[…] this surprised me a bit namely that she took the lead [in the group work] and is the one who speaks.*

Her response included much detail, listing coordinates of points A and B, and intercepts with both axes of the coordinate system as they changed in time. It invited an opportunity to support the student in moving from describing detail towards generalizing about patterns, but that opportunity was not recognized until later.

Edda explained that no extra support was provided for ILLs or their teachers at Mallard. When assigning students into random pairs, she strategically made one exception to make sure that the ILL who also was not fluent in English would be in a group of three:

Edda: But they were actually it was mainly the two of them doing the task.

Still, Edda's intention to create access was observed to have the effect that this student participated in the preparation discussion before the other two recorded the task response.

Discussion Along the Five TRU Dimensions

Comparing the two previous subsections, identifying opportunities and challenges that SVTs bring, some trends along the five dimensions of the TRU framework can be seen:

The Mathematics. Teachers were observed engaging students in an experience that contrasted with the prevailing sociomathematical norm about one correct answer. They gained insight into previously inaccessible information about students' mathematical ideas (including possible misunderstandings), and by repeated use of SVTs Orri raised his own awareness of the importance of precision when describing mathematical objects. It thus seems fitting to conclude that with SVT practices, teachers might support students' learning by raising their awareness of a) various explanations/descriptions existing, b) common misunderstandings related to the mathematical topic presented, and c) why precision is important in mathematical discourse.

Cognitive Demand. The teachers were observed attending to students who had a hard time deciding what to focus on in their task responses. This seemed to be due to the fact that the classroom environment involved mainly tasks with one right answer. We cannot be sure if students participating in SVT2 chose to lower the cognitive demand by only focusing on what they were absolutely sure about or if they simply did not think of line slope when watching the video. However, it is then the teachers' task to gather students' ideas about slope in the group discussion. In the discussion they will be given opportunities to make their own sense of mathematical ideas. Provided that teachers persist in taking on the (clearly identified) challenge of leading group discussions, they might establish that problems and misunderstandings will be discussed in an objective and meaningful way for the benefit of every learner in the classroom. In other words, they might create a safe environment for students to share their thoughts (erroneous or not) with others along the road.

Equitable Access to Content. To create opportunities for each and every student to participate in the mathematical communication of the class, teachers were observed adjusting their practices to make clear that everyone was invited to participate in the SVT and that everyone's voice would get listened and reacted to. With ILLs the adjustments were only partly successful, and therefore they remain to be developed further. For example, teachers might invite ILLs to create a task response in any language they are fluent in.

Agency, Ownership, and Identity. Students will not see themselves as powerful mathematical thinkers unless teachers treat them as such. This is connected with why teachers were asked to refrain from answering stop-thinking questions during task implementation. Also, it is connected with how problematic (but often tempting, therein lies the challenge) it is to turn back to teacher-centred practices, giving a lecture that does not connect to or meaningfully build on students' responses and ideas. For example, if teachers had prepared and played their own version of a task response for students, such an act would confirm students' observed expectation of a 'role model' response.

Formative Assessment. By insisting on using immediate feedback, teachers were observed to put extra strain on themselves in terms of orchestrating a meaningful classroom discussion based on their and students' reactions to students' responses in real time. Still, teachers' emphasis on immediate feedback made sense theoretically, in terms of Wright et al.'s (2018) list. In practice, one could imagine that lengthening the time between recording a task response and reflecting on peers' responses could make the experience more teacher oriented, as only the teacher would have had time to prepare. In one case, Orri was observed 'tying together' students' ideas at the end of class discussion. This happened during his third implementation and underlines that it takes experience, training, and reflection to develop discussion orchestration skills. By practicing and putting more emphasis on formative assessment and classroom discussions, teachers might prevail over the motivation role of the final grade, because more emphasis would be put on the process of learning than on the final grade.

Conclusion

This chapter described how SVTs can be implemented in the mathematics classroom and demonstrated how the TRU framework can be used to identify opportunities and challenges of technology-mediated FA practices for the teaching and learning of mathematics. Based on what was experienced by Andri, Edda, and Orri as they implemented SVTs in their classrooms, three opportunities (one of them also including a challenge) and four challenges were identified by analysing classroom observation and interview data via the lens of the TRU framework. The opportunities can be re-phrased as follows:

- SVTs have the potential to make previously unnoticed inconsistencies or problems regarding students' mathematical ideas (understanding) or ways in which they express their ideas (precision in word use) visible to teachers, thus, allowing teachers to address them.
- Situations created by SVTs might enable teachers to institutionalise knowledge.
- By offering students a new way of using technology for communicating (through implementing SVTs), teachers can include more students in the class discussion.

The first of these opportunities is important for FA practices since it helps raise issues that were previously implicit for teachers, which is one of the potentials identified by Wright et al. (2018). The second opportunity connects to three of Wiliam and Thompson's (2008) key strategies for FA (regarding providing feedback that moves learners forward, activating students as instructional resources for one another and as owners of their learning) because in a situation of institutionalisation, students' ideas are discussed and connected to mathematical objects that have previously been discussed in the classroom. In other words, students' ways of describing mathematics are given status by relating them to the ways that had been used by the teacher to describe mathematics. It is important to note, that the act of institutionalising knowledge implies learning as *acquisition* (of knowledge), whereas what was intended with the SVTs was learning as *participation* (Sfard, 1998; Sfard, 2008). However, learning as participation might be achieved by supporting students in the process of *reification* (Sfard, 2008), i.e. in their transition from describing processes towards talking about objects—a process that might be supported via students' participation in the group discussion.

Since the third in the list of opportunities in some cases demanded that teachers adapt the task in ways not necessarily obvious to them, it was also considered to be a challenge. Maybe due to their similarity to students' popular culture (e.g. YouTube, TikTok, SnapChat), the task of adding a voice-over to a silent video was observed to be easily understood by students. Apart from a few students who needed technical support with downloading software or uploading their recordings, the use of technology seemed to not be too much of a hurdle. What requires practice and support is mainly the facilitation of a meaningful discussion. Two of the challenges had to do with socio-mathematical and social norms. They might be country-specific, although the presented study cannot confirm that. These two challenges can be re-phrased as follows:

- Due to the prevalent norm in which students assume 'one correct answer' to exist, teachers can encounter tensions when implementing open tasks like SVTs.
- It can be cumbersome for teachers to enhance students' motivation in formative assessment practices when students are mainly driven by final summative assessment.

The other two challenges had to do with the way in which SVTs require teachers to shift to working in a socio-constructive way, basing feedback on students' ideas via discussion:

- It is challenging to lead group discussions based on students' ideas.
- It can be tempting to return to teacher-centred transmission of knowledge

These challenges are significant and important to acknowledge when teachers shift to technology-mediated FA practices. They connect both to key strategies for FA and potentials of technology-based FA strategies (Wiliam & Thompson, 2008; Wright et al., 2018). Teacher-centred transmission of knowledge can take the form of a lecture or a monologue spiced with a few questions such as "What is the slope when the line is vertical?" that reinforce students' perception that questions always having one right answer in mathematics. Considering the fact that most teachers are not used to implementing open tasks that require the use of technology and orchestration of classroom discussion, it is an understandable reaction to return to teacher-centred practices. Also, an implication that leading a discussion based on students' ideas might have longer-lasting effect on students' learning could be considered less important than the fact that such discussions often will require more time. However, if teachers are so restricted by tight time schedules that they make no time to get their students to think mathematically, something surely needs to change.

According to Mason (2002, p. 8) it is important for teachers to feel that they have made an informed decision in a moment of choice and responded professionally (based on awareness) rather than just reacted. There were indications in this study that a novice teacher using SVT practices started developing an in-the-moment awareness of possibilities for classroom discussion within one school term supported by the practice of reflection and think-aloud exercises. For him and the experienced teachers, the orchestration of group discussion was clearly the biggest challenge involved in SVT practices. Kooloos, Oolbekkink-Marchand, Kaenders, and Heckman (2019) described how support via a professional development course based on the work of Stein and Smith (2011) can support teachers who want to develop their practice of classroom discussions based on open tasks. Within four lessons, they supported a teacher to establish a discourse community in her mathematics classroom. For teachers who aim to include SVTs and similar practices—developing their ability to elicit, attend to, discuss, interpret, and respond to student thinking in their work—such professional development courses with like-minded teachers building a community of practice would probably be a good next step.

Acknowledgement

I would like to thank the editors of this book and the anonymous reviewers for their helpful comments. Also, I would like to thank the participating teachers for their active cooperation and readiness to illustrate complexities that they face in their everyday practice. This work was supported by the University of Iceland Centenary Fund and the Eimskip University Fund.

References

Aldon, G. (2014) Didactic incidents: A way to improve the professional development of mathematics teachers. In Clark-Wilson, A., Robutti, O., & Sinclair, N. (Eds.), *The mathematics teacher in the digital era: An international perspective on technology focused professional development* (pp. 319–343). Springer.

Aldon, G., & Panero, M. (2020). Can digital technology change the way mathematics skills are assessed? *ZDM*, *52*(7), 1333–1348. https://doi.org/10.1007/s11858-020-01172-8

Baldinger, E. M., Louie, N., & the Algebra Teaching Study and Mathematics Assessment Project. (2018). *The TRU math conversation guide: A tool for teacher learning and growth*. Graduate School of Education, University of California, Berkeley & College of Education, Michigan State University. https://truframework.org/wp-content/uploads/2018/03/TRU-CG-Math-2018-version.pdf

Bellman, A., Foshay, W. R., & Gremillion, D. (2014). A developmental model for adaptive and differentiated instruction using classroom networking technology. In Clark-Wilson, A., Robutti, O., & Sinclair, N. (Eds.), *The mathematics teacher in the digital era: An international perspective on technology focused professional development*. Springer.

Brinkmann, S., & Kvale, S. (2009). *Interviews: Learning the craft of qualitative research interviewing* (3rd ed.). Sage Publications.

Brousseau, G. (1997). *Theory of didactical situations in mathematics*. Kluwer Academic Publishers.

Cargile, L. A., & Harkness, S. S. (2015). Flip or flop: Are math teachers using Khan Academy as envisioned by Sal Khan? *TechTrends*, 59(6), 21–28. https://doi.org/10.1007/s11528-015-0900-8

Gattegno, C. (2007). The method of Jean Louis Nicolet. *Mathematics Teaching*, (205), 42–43.

Harðarson, A. (2010). Hvaða áhrif hafði Aðalnámskráin frá 1999 á bóknámsbrautir framhaldsskóla? [What effect did the National Curriculum Guide from 1999 have on academic study lines in Icelandic upper secondary schools?] *Netla – Veftímarit um uppeldi og menntun*. 19 pages. http://hdl.handle.net/1946/13799

Jónsdóttir, A. H., Briem, E., Hreinsdóttir, F., Þórarinsson, F., Magnússon, J. I., & Möller, R. (2014). *Úttekt á stærðfræðikennslu í framhaldsskólum* [Assessment of mathematics teaching practices in upper secondary schools]. Reykjavík, Iceland: Mennta- og menningarmálaráðuneytið. Retrieved from https://www.mrn.is/media/frettir2014/Uttekt-a-staerdfraedikennslu-i-framhaldsskolum-2014.pdf

Kitz, S. (2013). Dynamische Geometrie ohne Computer: Die mathematischen Trickfilme des Geheimen Schulrats Münch. *Mathematische Semesterberichte, 60*(2), 139–149. https://doi.org/10.1007/s00591-013-0124-y

Kooloos, C., Oolbekkink-Marchand, H., Kaenders, R., & Heckman, G. (2020). Orchestrating mathematical classroom discourse about various solution methods: Case study of a teacher's development. *Journal für Mathematik-Didaktik, 41*(2), 357–389. https://doi.org/10.1007/s13138-019-00150-2

Kristinsdóttir, B., Hreinsdóttir, F., & Lavicza, Z. (2020). Using silent video tasks for formative assessment. In B. Barzel, R. Bebernik, L. Göbel, M. Pohl, H. Ruchniewicz, F. Schacht, & D. Thurm (Eds.), *Proceedings of the 14th International Conference on Technology in Mathematics Teaching—ICTMT 14* (pp. 189–196). University of Duisburg-Essen. https://doi.org/10.17185/duepublico/70763

Kristinsdóttir, B., Hreinsdóttir, F., Lavicza, Z., & Wolff, C. E. (2020). Teachers' noticing and interpretations of students' responses to silent video tasks. *Research in Mathematics Education*. https://doi.org/10.1080/14794802.2020.1722959

Mason, J. (2002). *Researching your own practice: The discipline of noticing*. Routledge.

Oechsler, V., & Borba, M. C. (2020). Mathematical videos, social semiotics and the changing classroom. *ZDM*, 52(5), 989–1001. https://doi.org/10.1007/s11858-020-01131-3

Olsher, S., Yerushalmy, M., & Chazan, D. (2016). How might the use of technology in formative assessment support changes in mathematics teaching? *For the Learning of Mathematics*, 36(3), 11–18.

Pai, J. (2018). Observations and conversations as assessment in secondary mathematics. In D. R. Thompson, M. Burton, A. Cusi, & D. Wright (Eds.), *Classroom assessment in mathematics: Perspectives from around the globe* (pp. 25–44). Springer.

Schoenfeld, A. H. (2018). Video analyses for research and professional development: The teaching for robust understanding (TRU) framework. *ZDM*, 50(3), 491–506. https://doi.org/10.1007/s11858-017-0908-y

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4–13. https://doi.org/10.3102/0013189X027002004
Sfard, A. (2008). *Thinking as communicating. Human development, the growth of discourses, and mathematizing*. Cambridge University Press.
Sigurgeirsson, I., Eiríksdóttir, E., & Jóhannesson, I. Á. (2018). Kennsluaðferðir í 130 kennslustundum í framhaldsskólum [Teaching methods in 130 lessons in Icelandic upper secondary schools]. *Netla – Veftímarit um uppeldi og menntun., Special issue 2018: Focus on upper secondary schools,* 27 pages. https://doi.org/10.24270/serritnetla.2019.9
Sinclair, N. (2016). Learning circles: Imitation and imagery. *Mathematics Teaching*, (253), 11–14.
Stein, M. K., & Smith, M. S. (2011). *5 practices for orchestrating productive mathematics discussions* (1st ed.). National Council of Teachers of Mathematics.
Swan, M. (2006). *Collaborative learning in mathematics: A challenge to our beliefs and practices*. NRDC and NIACE.
Swan, M. (2017). Towards a task-based curriculum: Frameworks for task design and pedagogy. In T. McDougal (Ed.), *Essential mathematics for the next generation: What and how students should learn* (pp. 29–60). Tokyo Gakugei University Press.
Tahta, D. (1981). Some thoughts arising from the new Nicolet films. *Mathematics Teaching*, (94), 25–29.
Tahta, D., & Fletcher, T. (2004). *An account of the first decade of AT(A)M*. ATM. Retrieved from https://www.atm.org.uk/write/MediaUploads/About/History_Gattegno/an_account_of_the_first_decade_of_AT(A)M.pdf
van Manen, M. (2016). *Researching lived experience: Human science for an action sensitive pedagogy* (2nd ed.). Routledge, Taylor & Francis Group.
Venturini, M. & Sinclair, N. (2017). Designing assessment tasks in a dynamic geometry environment. In A. Leung & A. Baccaglini-Frank (Eds.), *Digital technologies in designing mathematics education tasks: Potential and pitfalls* (pp. 77–98). Springer.
Venturini, M. (2015). *How teachers think about the role of digital technologies in student assessment in mathematics* [PhD thesis]. University of Bologna.
Wiliam, D. (2011). *Embedded formative assessment*. Solution Tree Press.
Wiliam, D., & Thompson, M. (2008). Integrating assessment with learning: What will it take to make it work? In C. A. Dwyer (Ed.), *The future of assessment: Shaping teaching and learning* (pp. 53–82). Routledge. https://doi.org/10.4324/9781315086545
Wright, D., Clark, J., & Tiplady, L. (2018). Designing for formative assessment: A toolkit for teachers. In D. R. Thompson, M. Burton, A. Cusi, & D. Wright (Eds.), *Classroom assessment in mathematics: perspectives from around the globe* (pp. 207–228). Springer.
Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*(4), 458–477. https://doi.org/10.2307/749877