

Engineering Students' Experiences with GeoGebra and Student-Produced Screencast Assignments in Mathematics

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Abstract: This paper reports on engineering students' experiences from the introduction of GeoGebra/screencast assignments in two Mathematics 1 courses for engineering students. The purpose of the assignments was to help students gain a deeper conceptual understanding of mathematics by letting the students explore the mathematics in GeoGebra and to increase student engagement by asking them to present their knowledge in a screencast. The results show that students believe that they gain a better understanding of the topics compared to normal calculation assignments but that some challenges such as discomfort when presenting orally and the time required are prominent.

Keywords:

Mathematics, GeoGebra, Student-produced screencasts

1 Introduction

1.1 Background

In an attempt to shift mathematics teaching towards a clearer focus on conceptual understanding, a new type of assignments has been introduced at UiT - The Arctic University of Norway, campus Narvik in the course Mathematics 1 for engineering students. In the assignments students build a dynamic GeoGebra construction and use it to show and explain mathematics in a screencast.

Conceptual knowledge is defined by Hiebert (1986) as knowledge that is rich in relationships. This means that one unit of conceptual knowledge cannot be an “isolated piece of information” but that the knowledge is connected to other pieces of information to a web of knowledge. On the other hand, Hiebert describes procedural knowledge as formal mathematical language (knowledge of symbols and syntactic rules) and “algorithms, rules and procedures”. Conceptual knowledge must be learned meaningfully, that is it must somehow be linked to other pieces of knowledge. Procedural knowledge on the other hand can be either learned in isolation or meaningfully. A procedure one learns can be put in context and understood how it relates to other pieces of information and how and when it can be used, but it can also be learned without any context whatsoever, without knowing what it should be used for or under which circumstances. The two types of knowledge are distinct but lie on a continuum and are mutually beneficial (Hiebert, 1986; Rittle-Johnson et al., 2001). Procedural knowledge is important for learning mathematics, but the problem is that much teaching tends to focus almost exclusively on procedural knowledge. When learned through imitation without proper understanding, this knowledge does not help students engage in mathematical reasoning on the higher cognitive level required for deep learning. The goal of the assignments discussed in this paper was to shift students away from the predominantly procedural and imitative approach that otherwise characterizes much of their mathematics education. This was done by giving students conceptual mathematics tasks that required exploration in GeoGebra and by making them explain their understanding in a screencast.

Dynamic Geometry Software (DGS, such as GeoGebra) are powerful tools that have become increasingly popular in mathematics education in recent years. DGS allows students to explore mathematical concepts and visualize geometric figures in a dynamic and interactive way. GeoGebra, which is the DGS tool used in this study, provides the opportunity to build one’s own construction from the ground up and the students can in this way be both active and creative participants. This can help students develop a deeper understanding of mathematical concepts and gain more intuitive insights into the correlations between mathematical ideas, foster creative reasoning, and provide a platform for sharing reasoning (Olsson, 2017; Villa-Ochoa & Suárez-Téllez, 2022). This process is by no means automatic (Jones, 2005), but requires guidance from the teacher, well designed tasks, and opportunities for students to discuss mathematical meaning.

To increase students’ level of engagement with DGS tasks, they can be required to present their work in an oral presentation. Oral presentations have been shown to increase students’ metacognitive regulation (Naalsund & Skogholt, 2017) and are beneficial for students’ long-term learning (Fiorella & Mayer, 2014). Practicing

communication can in itself be considered a learning goal since it is included as one of four important competencies for future students in a report from the Norwegian ministry of education and research (NOU 2015:8). Several benefits have been observed from giving oral presentations in comparison with written presentations. Among other things oral presentations have a tendency to be longer and more elaborative in comparison with written explanations, whereas written explanations tend to be more organized (Lachner et al., 2018). Live oral presentations have the downside of being impractical in large classes. In particular, a lot of time needs to be allocated for the presentations. Such presentations are therefore often performed in groups, but even so, for classes of hundreds of students this still requires a lot of teacher resources. In addition, low performing students can often “hide” behind their more capable group peers and not participate in the presentation as much as one would like. An alternative that has become increasingly popular in recent years is to instead have the students make their presentations in the form of a screencast. A screencast is a digital video recording that captures the output displayed on a computer screen along with an accompanying audio narration. Screencasting has the same benefits as regular oral presentations but also offers some additional benefits: (1) The student can do as many retakes as necessary, which gives the student more practice and presumably reduce the student’s anxiety in comparison with a live presentation; (2) the screencast can be made whenever, and wherever the student prefers; (3) the screencast can be edited, mistakes and unnecessary parts removed, corrections and clarifications added, important areas of the screen highlighted, etc.; (4) time is much less of an issue which means that all students can be made to participate and do a full presentation; (5) the students learn to use technology; (6) screencasting is compatible with other digital tools, such as GeoGebra, PowerPoint, document camera, video, images, sound, animations, webpages, etc.; and (7) the product can be shared and used for teaching, self-evaluation, peer-review and assessment. Screencasting requires some equipment such as a computer or a tablet; a microphone; possibly, but not necessarily, a camera; and software for recording and editing. Computers and microphones are equipment that almost everyone already have access to, and in the present “YouTube-era” software for recording and editing screencast is readily available, often for free. One drawback of screencast presentations is the absence of real-time interaction, which makes it impossible to pose questions to the presenter or engage in live discussions.

Several previous studies exist on the use of screencasting in various subjects. For example, Yang and Lau (2018) found that university students who recorded a screencast in groups while solving problems, could remember the content better and found the exercise motivating. The students in that study were quite positive to the approach. Other researchers have also noted several positive effects, such as increased mathematical understanding and improved technological skills (Croft et al., 2013; Galligan & Hobohm, 2018; Soto, 2014).

Few studies have been found that use both DGS and screencasting, Shafer (2010) and Lazarus and Roulet (2013) being exceptions. Out of these Shafer (2010) is the most relevant. The students in that study were required to use DGS (The Geometer’s Sketchpad) to make screencasts that demonstrated their understanding and explanation of geometric proofs. The study included a peer review element where the students’ watched and discussed each other’s screencasts. The objective with the study was to investigate “whether or not creating and sharing screencast proofs would help

students value geometric proofs as a means to explain and communicate important mathematics". Shafer found that students valued the use of technology to communicate mathematics and that the task made the students into decision makers and producers instead of passive participants. This result is interesting and shows the potentiality of using DGS and screencasting to learn mathematics and practice communication skills. Shafer also reports that the peer review process was just as or more important for the students as their own screencast production for developing skills at writing and evaluating geometric proofs. A critique I would like to raise, however, is that the student's own screencast production most likely is a prerequisite for proper engagement with the other students' screencasts and its importance should therefore not be underestimated.

1.2 The present study

The present work aims to contribute to the field by further exploring the possibilities and limitations of combining DGS and screencasting, both of which are highly interesting in mathematics education research.

Specifically, this study reports on engineering students' experiences with GeoGebra and screencasting assignments (GG/SC) introduced in the course "Mathematics 1" at UiT Narvik. The combination of DGS and screencast presentations was hypothesised to be a powerful combination for students to actively engage in mathematics on a deeper level. The assignment design is based on constructivist thinking in that in this theory effective learning is accomplished by being actively engaged with the subject at hand and building up your own knowledge through participation instead of passively receiving it. "Knowledge is constructed by learners as they attempt to make sense of their experiences" (Driscoll, 2004, p. 387). Mayer (2004) says that "A basic premise in constructivism is that meaningful learning occurs when the learner strives to make sense of the presented material by selecting relevant incoming information, organizing it into a coherent structure, and integrating it with other organized knowledge", which relates to the "web of knowledge" which is characteristic of conceptual knowledge (Hiebert, 1986). GeoGebra allows the students to explore, experience and make sense of the mathematics, and screencasting requires the student to select and organize the information, and also requires the students to articulate and explain mathematical meaning. The combination of the two is therefore assumed to make the students active and cognitively engaged with the mathematics, which is essential for meaningful, conceptual learning (Mayer, 2004).

Since the assignment design introduces several new elements (software, type of tasks and mode of presentation) that most students are unfamiliar with, it was expected that many students would find the assignment quite challenging but rewarding. The purpose of this study is to gain an understanding of how the assignments were perceived in order to facilitate further development of the design.

The questions this paper aims to answer are:

1. How do students experience these assignments regarding learning, challenges, workload, etc.?
2. What are the main reasons for students' sentiments about the assignments?
3. How do students' sentiments of the assignments change as they gain experience with the assignments?

2 Method

2.1 Participants

The participants were engineering students from two different Mathematics 1 courses (2021 and 2022, 10 ECTS over one semester) at UiT. Students belonged to different programs such as, construction engineering, electrical engineering, process technology, mechanical engineering, and computer science. The students belonged to different campuses (Narvik, Alta, Bodø and Mo) and there was also a large (~50%) group of online students. In total more than 300 students completed at least one GeoGebra/screencast assignment. Most of the participants (~70%) had very little or no experience with screencasting before the assignments. Due to the use of GeoGebra in Norwegian upper secondary schools, around 50% of the students had significant experience with the software.

2.2 Assignments and task design

The students were given two GG/SC assignments during the course. All students recorded their own screencasts. No restrictions were otherwise placed on the students, for example with regards to cooperation. In this way, the assignments, despite being part of a research endeavour, were conducted in an authentic educational setting. In advance of the assignments, information was provided to the students regarding how to complete the assignments. This included suggestions regarding what software to use (GeoGebra and screencasting/video editing software), and how to deliver the completed videos. The biggest difference between the two years is that in 2022 the students had access to a “guide video” (similar to a “video model” used in e.g. Omarchevska et al., 2022) that gave the students support on both the mathematics and how to build the GeoGebra construction, while in 2021 the students only got instruction on GeoGebra in written form in the task sheet. The students did not upload videos to the LMS but to a cloud storage site (OneDrive, Google Drive, etc.) or YouTube (with the suggestion not to make the video public). The students would then post the link to the video in the LMS.

All software recommendations were accompanied by an instruction video, produced by the author, that contained the necessary information on the basic functionality of the software. The suggested software was GeoGebra, and ActivePresenter for screencasting and editing. The students did not record their face, only screen and voice. In addition to the two GG/SC assignments, two regular assignments with calculation tasks were given during the course. Due to a requirement in the course that only 3 out of 4 assignments had to be submitted, the number of screencast submissions dropped from around 170 for the first assignment (A1) to fewer than 100 for the second (A2) for both years.

Figure 1 gives an overview of the assignments and data collection.

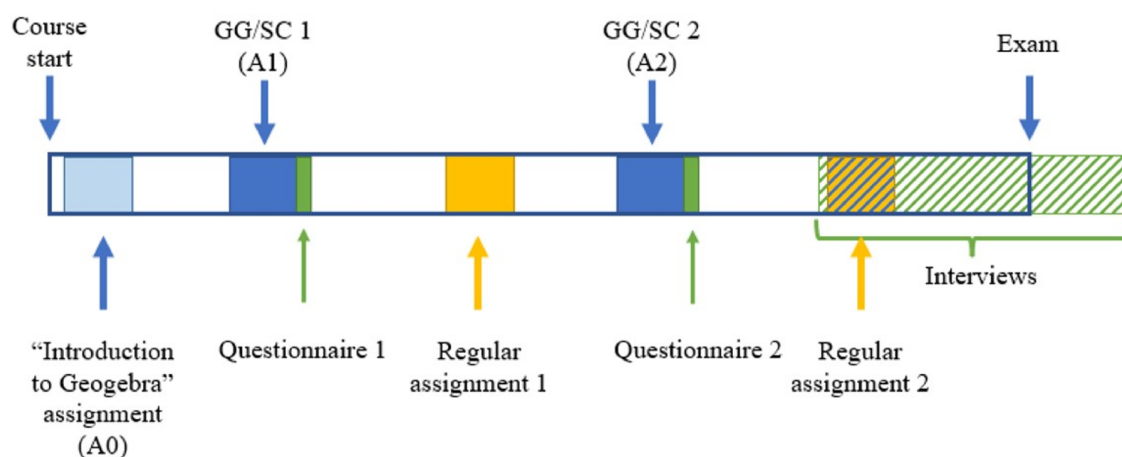


Figure 1. Overview of assignments and data collection during the course.

The topics of the assignments were complex numbers and Taylor polynomials. These were chosen because they are suitable for visualization in GeoGebra and the timing was appropriate within the course curriculum. The assignments for the two years were similar but not identical.

The researcher was not directly involved in teaching the course. Involvement was limited to the design, feedback and grading (pass/fail) of the assignments.

2.2.1 Task design

The tasks were created such that the students would build their own GeoGebra construction, explore the mathematics, find patterns, and explain concepts/relationships. The tasks were designed using the recommendations of Trocki and Hollebrands (2018). According to this framework for task design in DGS, high-quality tasks should co-ordinate technological actions with mathematical depth. The DGS tasks should prompt the students to construct and manipulate a DGS “sketch” and require the students to explore the mathematical relationships and explain mathematical concepts, preferably resulting in the conjecturing and the construction of proofs. (Leung (2011) presents a similar framework for DGS task design.) All tasks in the current study were of a “show and explain” type. Tasks of the type “show and talk about the solution to a calculation problem” were avoided because they tend to result in imitation and “knowledge-telling” (summarization with little monitoring or elaboration) (Roscoe & Chi, 2007). Since engineering students do not specialize in mathematics, the tasks were not designed to meet the strictest requirements in Trocki and Hollebrands’ framework (i.e., the construction of formal proofs). In addition, consideration has been given to the fact that you should be able to complete the assignment even if you are a less proficient student.

2.2.2 Voluntary preparatory assignment (A0)

A voluntary assignment, “Introduction to GeoGebra”, was provided at the start of the course to help students familiarize themselves with GeoGebra and screencasting if necessary. (This assignment will be referred to as A0). The task was to make an

instruction video about the basic functionalities of GeoGebra. Around 50% of the students completed this assignment.

2.2.3 Assignment 1, Complex numbers (A1)

Each course had two screencast assignment and the topic of the first assignment (A1) was complex numbers. The students had three lectures (in total 4.5 hours) about complex numbers before the assignment. No digital visualization tools were used in these lectures. At the start of the task sheet, an instruction was included for how to build a simple GeoGebra construction that met the minimum requirements needed to complete the task. (These instructions came in the form of a guide video in the 2022 course.) The focus in the assignment was multiplication of complex numbers and how it graphically corresponds to rotations and dilations in the complex plane. Examples of tasks were:

- Use your GeoGebra construction to explain the formula $z_1 \cdot z_2 = r_1 \cdot r_2 \cdot e^{i(\theta_1 + \theta_2)}$
- Show and explain where the solutions to the equation $z^5 = r \cdot e^{i\theta}$ are located in the complex plane.

Figure 2 is a screenshot from a screencast by a student who is discussing the second of these two example tasks.

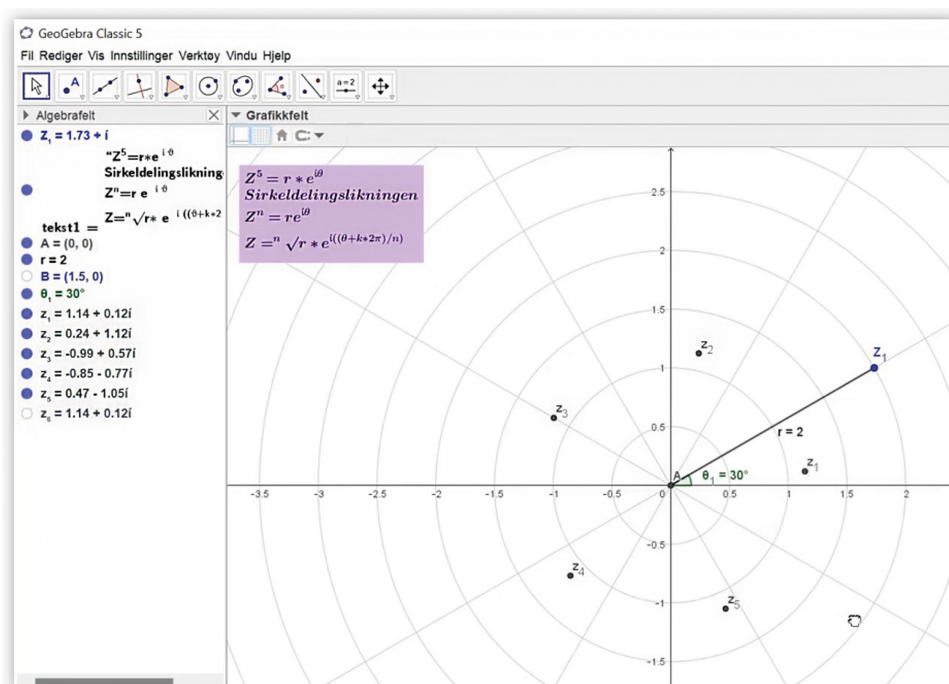


Figure 2. Screenshot from a student screencast about complex numbers.

2.2.4 Assignment 2, Taylor polynomials (A2)

The topic of the second screencast assignment (A2) was Taylor polynomials. The students had one lecture (1.5 hours) about Taylor polynomials before the assignment. No digital visualization tools were used in these lectures. The focus in the assignment was on how the properties of the original function are inherited by the polynomial

depending on the degree, and how the polynomial can be used to approximate the original function. An example of the tasks is:

- A function $f(x)$ and its Taylor polynomial of the zeroth degree, $P_0(x)$, have the same value at the center point. The polynomial of the first degree, $P_1(x)$, in addition has the same first derivative as $f(x)$. $P_2(x)$ has the same second derivative, and so on. Show and explain what is meant by this.

2.3 Data collection and analysis

To seek answers to the research questions, anonymous questionnaires were distributed after each assignment (two per course) and interviews were conducted at the end of the course (see Figure 1). The questionnaires were distributed digitally via the university LMS. Most questions in the questionnaires were of a Likert type, but some questions were open-ended. The purpose was to get an overview of students' general sentiments, main challenges, workload, perceived learning outcomes, time spent on task and how their perceptions changed over time. The response rate was 60% after A1 but dropped to around 40% after A2. The questionnaires were not based on any existing instrument. The questionnaires were slightly reworked after the first year, meaning that the contents of the questionnaires and phrasing of the items were not identical for the two years.

The interviews were aimed to get a more in-depth view on the same issues as the questionnaires. The interviews were semi-structured, conducted online (Zoom), and followed a hierarchical focusing design (Tomlinson, 1989) to avoid leading questions. The requests for students to participate in the interviews were distributed via the LMS to all students who had submitted at least one screencast. The results and conclusions presented here are based on eight interviews.

Both open ended questionnaire responses and interview transcripts were coded and the most prominent themes regarding the research questions were developed using Thematic Analysis (Braun & Clarke, 2022). Thematic analysis (TA) is a widely used method in qualitative research to systematically identify patterns and meanings within data sets which are then analysed and interpreted to generate insights into the research questions and presented as themes. In the present study an inductive (data driven) approach to TA is taken where the themes developed are not part of any predefined framework. This methodology was considered particularly suited for this exploratory research due to the complex educational setting of the assignments. In line with the reflexive approach of this methodology, researcher subjectivity is acknowledged, and the results should be understood accordingly. The themes presented are considered to be the most salient in capturing the students' experiences, and the included quotations have been chosen to accurately reflect the various perspectives of the students. All quotes are translated from Norwegian.

All participants in this research, both interviewees and questionnaire respondents, were informed that their participation was part of a research project and have consented to the use of their responses in publications. Verbal approval was obtained from the interviewees, while questionnaire respondents provided their approval implicitly by choosing to participate. Approval for this project has been obtained from the Norwegian Center for Research Data.

3 Results and discussion

The main themes identified in questionnaire and interview data regarding student experiences were: Perceived increase in learning/understanding, Discomfort, and Excessive time use. These are discussed below as are the main challenges identified, but also how the students' sentiments changed over time.

3.1 Perceived increase in learning/understanding

According to the questionnaire after A1 2022, 73% of the students report that they have a positive or very positive sentiment of the assignments (Figure 3).

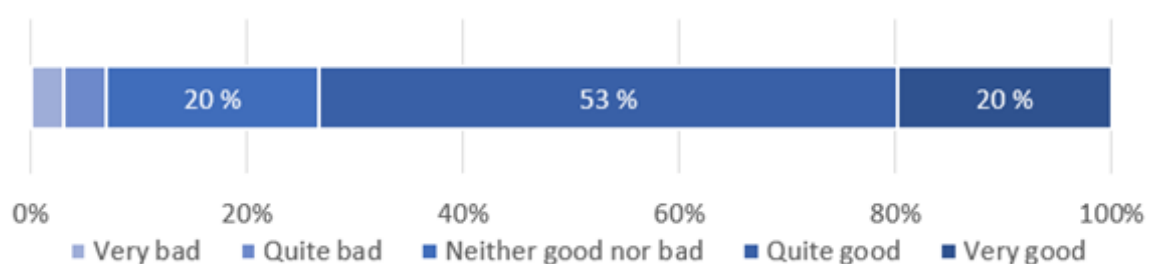


Figure 3. What is your general assessment of the assignment? (A1 2022, n=101).

The reasons for the students' positive experience are mixed, but out of 55 answers to an open-ended question (after A1 2022) about what was most positive about the assignment, 30 in some way included references to increased understanding or learning of complex numbers. One example of such a comment is:

“In subjects such as mathematics, it is often the case that you follow a set of rules to perform arithmetic operations. In this type of assignment, the focus is more on understanding the underlying subject matter, and you learn more about why things are the way they are.”

In this comment it is not clear why the student experienced increased learning other than that the “focus” is more on understanding. Many students highlighted “visualisations” in GeoGebra as a source of understanding, but a more frequent comment is on the theme “forced learning”.

“I think you are forced to understand what you are doing if you are to explain in your own words rather than solving mathematical problems with pen and paper. I think this is a challenging but good way to learn.”

Other comments in a similar way indicate that it is explaining in a screencast that “forces” the student to study the material more deeply.

“You force yourself to understand the mathematics better when you have to explain. There are probably many things I would have taken for granted if I didn't have to understand/explain to such a large extent.”

And

“Yes, so the screencast... it was having to make the screencast that forced me to do the task itself. If it had not been for that, I would have just maybe watched a video. I would not have thought much about it, not done much with it. So it was a kind of motivation that I had to have something to show, I had to have a video with a screencast. So that was the driver for understanding, to have something good to say. Suddenly someone was going to see it, it was not just for my own sake or like 'now I have worked for half an hour on this math problem, so now I can go do something else.' It becomes like 'Now I have worked for half an hour and now I just have to keep going and get it done, because someone is going to see it.' So it is motivation to do things properly.”

The last student quoted here clearly refers to screencasting as an extrinsic motivation (Ryan & Deci, 2000) to do things properly because “someone is going to see it”. This is interesting because someone “sees” a written assignment as well but a screencast seems to induce a stronger sense of social presence. Lachner et al. (2022) discusses the “social presence view” and how it can explain the learning-by-teaching effect during non-interactive teaching. It says that students learning from non-interactive teaching (e.g. screencasting) can be partly explained because the students generate additional elaborations during their teaching to make the content more comprehensible when they have an audience in mind. A second explanation can be that physiological arousal caused by performing for an audience (real or imagined) can have various positive (and negative) effects on learning. A third way a sense of social presence can affect learning is that it is motivational, thereby encouraging the students to spend more time studying. The present case seems to fit the first and third explanation best as they both are related to time spent on task and the first also explicitly refers to the quality of the presentation. To what degree a feeling of social presence actually facilitates learning is unclear (Lachner et al., 2022), but it is clearly a factor that affects how the students approach the tasks.

The other 25 comments on what was most positive about the assignment included points such as "Learning of GeoGebra" or "easier to remember", some of which might also be in the category of "learning mathematics". The students' answers show that not only do a large part of the students feel that they learn more but that they focus more on studying for understanding simply because they have to.

Many students also comment that they, in the act of explaining, become more aware of their own lack of understanding.

“The first thing about explaining to someone is that you notice if you have gaps in your understanding. [...] You notice if you have to stop and think while you are explaining.”

Over 80% of the students after A1 in 2022 agree or completely agree that “Compared to solving traditional problems, this type of assignment provides greater self-awareness of one's own knowledge level.” Some students comment that calculations do not have the same effect.

“I really enjoyed working on those tasks. I had to sit down and do the calculations first of course and try to see what the answers would be. And that would be the usual "get it into the muscle memory", not so much understanding. You just see the task and then the hand takes over. When I was done with that part, I had to go through it all and

explain. Since there was no one watching, I was actually just sitting there explaining to myself "Why did I do these things?", "How did I arrive at this answer?", "What will the graph look like if I change the constant to such and such a value?", and so on."

This quote from one of the interviews shows that the student is aware of the difference between procedural learning and a more conceptual learning approach. He also asks himself important metacognitive evaluation questions during the work with the assignments, which can be assumed to be beneficial for learning and often occurs during oral presentations (Naalsund & Skogholt, 2017). In addition to the "social presence view", Lachner et al. (2022) discuss the "generative processing view" of learning-by-teaching which posits that "students primarily learn from the cognitive and metacognitive learning processes that occur during the reconstruction of information". Generative processing is "building a new mental representation based on one's relevant existing knowledge" (Fiorella & Mayer, 2016). Fiorella and Mayer further says that "Taken together, metacognition and motivation are the power source of generative learning". A feeling of social presence motivates the students to do the work and do it properly, but it is the generative cognitive processing that occurs during the explaining that facilitates learning. Fiorella and Mayer explains it like this: "even if learners possess strong metacognitive skills, they still must be motivated to initiate and maintain generative processing—that is, they must be willing to invest cognitive effort toward making sense of the material during learning". Conceptual learning does not come without spending cognitive effort and the screencasting tasks can provide the necessary motivation and at the same time facilitate metacognitive monitoring.

The results presented here concern perceived learning and not actual learning, and these two are of course not necessarily the same. The point here is therefore not that the students necessarily learned more mathematics in absolute terms but that many of them clearly noticed the shift in focus from procedural to conceptual understanding, most appreciated this change and that they believe that the intervention was successful.

3.2 Discomfort

A theme that very commonly appears in the data is "discomfort". The most common complaint on this theme is "discomfort with hearing one's own voice". After A1 about 50% of the students "agree" or "completely agree" that it is unpleasant to record an oral presentation (~30% completely disagree).

"The most awful thing about these assignments is definitely that you have to record it, and then have to hear your own voice afterwards trying to explain things that you're not always 100% sure of."

One student, who was requested to participate in an interview specifically due to his negative sentiments of the assignments, said

"For me, the biggest [problem] is my voice [...]. Hearing myself. I feel like it puts a brake on everything else."

It also appears as if many students feel more exposed when doing a screencast compared with a written assignment. Some students complain that the assignments are "revealing" and therefore make them feel uncomfortable.

“First of all, it is that is so revealing how little you understand. It is very unpleasant to present something you don’t understand 100%.”

When the screencast assignments were introduced, it was anticipated that the students would feel relatively low levels of anxiety due to the possibility to rerecord if they were unhappy with their screencast. This is also confirmed by some students. One student for example explains:

“you get a completely different type of stress [...] from a written presentation compared to this oral, or visual, video presentation. I didn't feel as stressed about having to explain what I was doing. If I made a mistake, I just smiled and then edited and redid it.”

Other students, however, felt high levels of anxiety due to the impression that the screencast assignment placed a high demand on them to submit a high-quality product.

“I feel that when you record and submit a video, that it then automatically places a higher demand on the structure and presentation. There is in a way a final product that lives forever. But when the presentation is live, it just happens there and then.”

Thus, screencasting can both reduce or increase anxiety of presenting, depending on the perspective of the student.

The two different types of discomfort: discomfort from hearing your own voice and discomfort due to the revealing nature of the presentation mode (or "video medium") was also identified by Martin et al. (2013). The two different types of discomfort have different solutions from the student’s perspective. The first type of discomfort is simply due to an unfamiliarity with how one’s voice sounds to others. The solution, other than avoidance, is most likely to simply get more exposure to hearing your own voice. The other type of discomfort is solved by making an extra effort to produce a presentation that you can be proud of. This feeling of discomfort is thus not strictly negative if it results in an appropriate amount of increased effort. This relates to the earlier discussion on “forced learning” in section 3.1. However, as will be discussed in the next section, screencasting seems to have the tendency to make students use an inappropriate amount of time to produce high-quality products, and this can be quite ineffective with respect to learning mathematics.

3.3 Excessive time use

Out of 123 comments on what was the worst aspects of the assignment A1, 55 in some way were about the time required to complete the assignment. This was an expected result since the same has been reported in other studies on student-produced screencasts (Galligan & Hobohm, 2013; Speed et al., 2018) and for many students this was the first time they had been given an oral presentation task in mathematics, used GeoGebra or recorded/edited a screencast.

Of those students that specify what it is that is time consuming, many put the blame on recording and editing. For example,

“[The worst thing was] That I had to spend so much time on recording and video editing, I am not a computer expert, I would rather spend the time understanding the mathematics.”

Exactly what “recording” entails is not always clear from the students’ comments (technological issues, learning the software and formulating an explanation can all affect recording time) but as will be discussed in the next section (3.4 Main challenges) it seems as if “explaining” is the most difficult aspect. One student comments:

“It took a lot of time. I feel like I never get finished. I always want to redo the recording.”

Inexperience with the various software can likely explain a large part of the time needed to complete an assignment, but to “redo” the recording is a factor that can be quite significant. Since many students feel that screencasting places a high demand on the presentation, even small mistakes in many cases result in a retake of the whole task instead of a simple correction (as one would have done in a live presentation). Such retakes are very time consuming. Students who do not use editing software are particularly affected by retakes since they must redo the whole screencast. While it is desirable with high quality products from the students, you do not want them to spend an unreasonable amount of time on small details in the presentation. Preferably the students should spend their time and efforts on the mathematics. It can therefore be advisable to reduce the surface-level quality demands on the screencasts and ensure the students are aware of this. Many previous studies on student-produced screencasts have had as a goal that the screencasts are to be used for peer-review (Croft et al., 2013; Galligan & Hobohm, 2018; Keane & Loch, 2017). This can have several benefits for both creator and peer-reviewer (See Ribosa and Duran (2022) for a literature review concerning Student-Generated Teaching Materials in general) but will at the same time probably increase the time students spend on recording and editing. This trade-off is important to consider when implementing this type of task.

In the assignments described here, no strict time limit was placed on the students’ screencasts. It was, however, mentioned in the instructions that they should preferably limit the time to around 10-15 minutes. The time limit was originally meant to reduce the amount of work for the students (as well as for the teacher who must assess all screencasts) but in some cases it had the opposite effect. Some students mistook the suggested limit for a strict limit and spent much time editing the screencast down to 15 minutes, which is a wasteful use of the student’s time. (In one case a student avoided cutting anything out by instead increasing the speed of the video.) Since the purpose of the GG/SC assignments, among other things, is to make students talk about mathematics, it is in a way counterproductive to artificially limit the amount of time you let students speak. Many students speak at a quite slow pace, which is unfortunate if the time limit is strict. Screencasting has the benefit, in comparison with a live presentation, of allowing the student to use as much time to explain as she needs and wants. Presumably, provided that what is said is correct, the more the student talks the better, and long screencasts should not be seen as problematic unless they are to be reviewed by peers. When it comes to assessment, although longer screencasts may take more time to review and give feedback to, a thorough analysis of the entire screencast is often not required to provide a fair evaluation.

The time required to complete an assignment naturally also depends on the difficulty level and the number of tasks involved. While some students have commented on these aspects as well, they are not included in this discussion since such factors are inherent to all forms of assignments.

3.4 Main challenges

After A2 (2022) the students were asked about the main challenges they faced while working with the assignments (Figure 4).

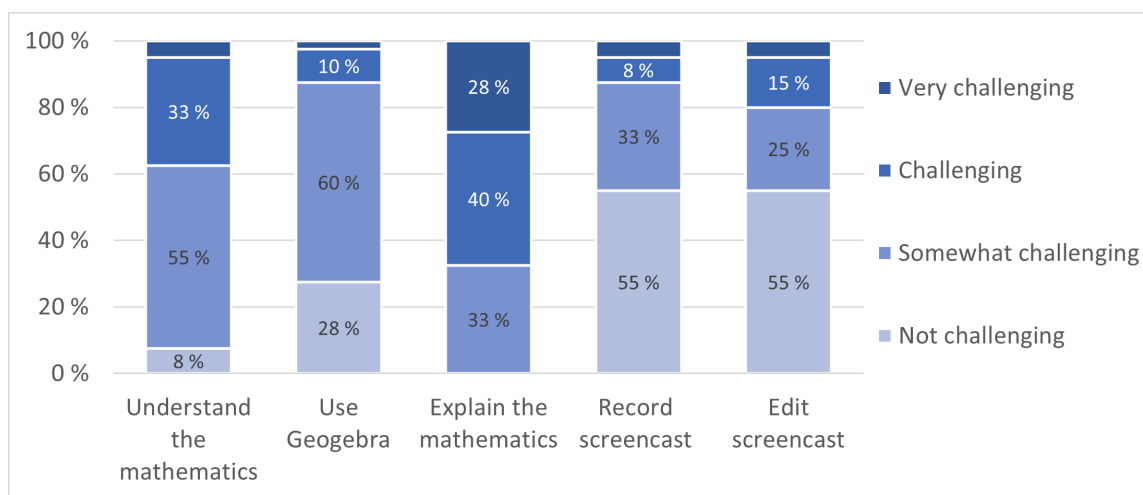


Figure 4. How challenging were the different parts of the Taylor polynomial assignment? (A2 2022 $n=40$, 40% response rate)

38% of the students report that it was challenging or very challenging to understand the mathematics, but 68% report that it was challenging or very challenging to explain the mathematics. None of the respondents answered "not challenging" when asked about explaining the mathematics. When asked about recording the screencast (and specifying that it was the *technical* aspect of recording that was intended) only 13% answered that it was challenging or very challenging. The corresponding number for "edit screencast" was 20%.

"The screen recording software itself was not challenging to use, but explaining things correctly in combination with demonstrating them on GeoGebra was a bit difficult. For example, making mistakes or using incorrect terminology and having to start the recording again."

"The only thing that was tricky was articulating myself."

"I find it uncomfortable to listen to my own voice and difficult to talk about mathematics even if I understand it."

Taken at face value these results indicate that the main struggles for the students are not technological issues (unlike what was reported by Yang and Lau (2018)) but rather mathematics (understanding and explaining), which is a positive result since that is exactly where we want the students to spend their efforts. However, some students do report that they experience significant frustration with the assignment due to software or equipment such as microphones.

A limitation of these results is that only around 50% of the students did assignment A2 in 2022 and only 40% of those who completed the assignment answered the questionnaire. A similar question on the questionnaire after A1 (with 101 respondents) did not separate out the category "Explain mathematics" from "Record screencast" and

in this case 48% of the students reported that recording screencast was “Not challenging” while 23% answered that it was challenging or very challenging.

3.5 Change of sentiment

Since most of the reported challenges were “discomfort” or time requirements due to recording and editing, one might expect that the sentiments would improve when their experience with the assignment type, software, etc., increases. This is confirmed in the student responses after A2 (2021 and 2022) as shown in Figure 5.

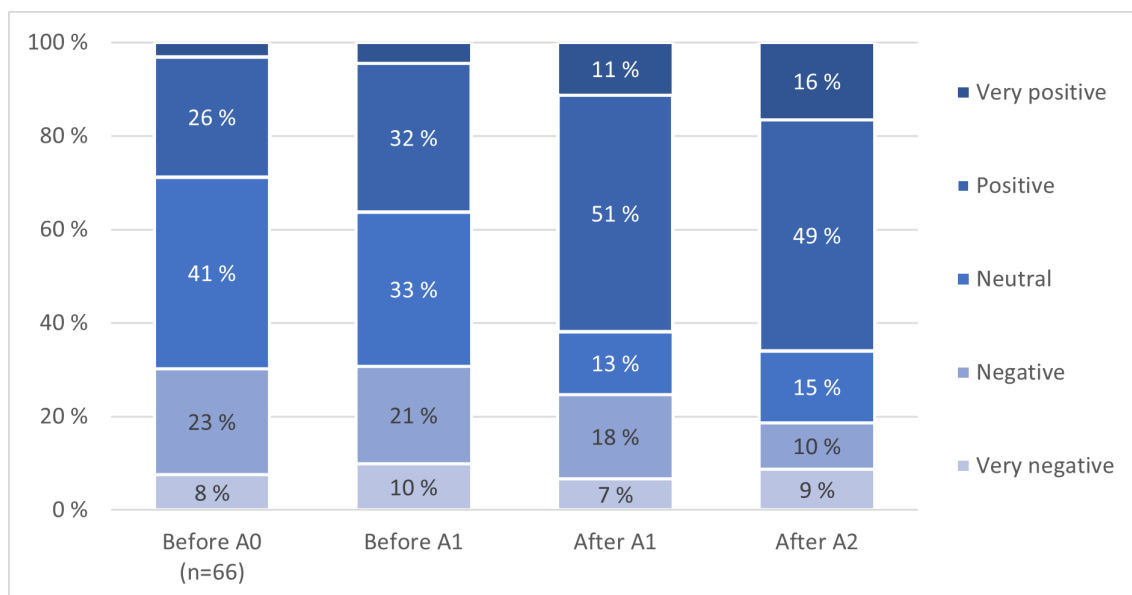


Figure 3. How has your general sentiment of the GeoGebra/screencast assignments been at different stages of the course? (Data from two years, n=86)

The group with the biggest change is the “neutral” group. Of the 29 students in this group before A1, only one had a worse sentiment of the assignments after A2, 7 students kept the reported sentiment as “neutral”, and 21 students report an improved sentiment. On the question “Would you rather choose to do a written assignment instead of a video assignment?” one student answered

“I would most likely [have chosen a written] if video was not required, but now when I have experienced how much you learn I would have chosen video assignment.”

This type of response, “I would have chosen a written assignment, but...” is quite common. Out of 67 responses after A1 in 2022, 41 would have chosen a written assignment. Out of these, 14 answers include some sort of concessive clause (“but...”). Other examples are:

“I probably would have chosen written because this was "scary and new", but in hindsight it was instructive and I'm glad I did it.”

“I personally would probably have chosen the "safest" type of assignment, written assignment. That's why I'm glad you couldn't choose it. I was able to challenge myself when we had to make a screencast and am left with a higher understanding of the topic of complex numbers, a much greater knowledge of GeoGebra, as well as a sky-

high sense of mastery and motivation. I now use GeoGebra to better visualize the math in other subjects, and I have also found use for screencasting in other subjects.”

Typically, the reason for choosing a written assignment is the time aspect, unfamiliarity with screencasting, discomfort with oral presentations, or simply that written is “easier”. The reason for including the concessive clause is almost exclusively due to perceived learning gains.

Some students are quite negative to the approach even after having experience with two (or three, counting A0) GG/SC assignments. The reasons are usually that the students feel that the assignments are too time consuming, that the topics of the assignments were too narrow and/or that they have limited relevance for the exam.

“I prefer regular assignments as I feel I use the time more constructively for learning, and that they more resemble an exam situation.”

“I would have chosen written answers because the exam is in writing, and it is therefore important to practice quantitatively on a variety of tasks.”

“What I think can be problematic with video assignments is that they go very in-depth on a small part of the semester's mathematics. If one had similar tasks for each chapter, it would probably be very instructive.”

One can conclude that good task design is not only important to maximize learning, but also to motivate the students. The tasks in the GG/SC assignments were relevant for the exam but not obviously so. A clearer alignment between the assignments and exam would probably have been beneficial. As long as the exam is mainly based on problem solving “calculation” tasks, the “show and explain” type of tasks should perhaps be integrated with a problem-solving component. The criticism that the topic of the assignment is too narrow is legitimate but was a result of the trade-off between breadth and depth. It is also the case that a wider scope of tasks would have made the GeoGebra construction more complicated, to the students' detriment.

From “after A1” to “after A2” the sentiments did not change very much. 15 students out of the 86 report an improved sentiment and 8 students reports a worsened sentiment. One student comment:

“Doing the assignment became easier because you have acquired better techniques. This meant that mathematics became the focus of the last assignment, while on the first one you only hassle with the equipment.”

It should be noted that the data presented in Figure 5 only includes students who completed both A1 and A2. It can be considered likely that the most negative students did not submit A2 and are therefore not part of this data. In a separate question about the student's general perception of the assignment in the questionnaire after A1, however, the percentage of students that were positive or very positive was 73% (i.e., even higher than in Figure 5).

4 Summary and conclusion

This paper reports on students' experiences with assignments consisting of mathematics tasks in GeoGebra and reporting their work through student-produced

screencasts. Students experience the GeoGebra/screencast assignments in very different ways. Many students say that their understanding increased more compared to regular calculation tasks, the reason being that they are “forced” to study for understanding because they have to explain the mathematics in the screencast. This result may be attributed to the “learning-by-teaching effect” (Lachner et al., 2022).

Numerous students are, however, very uncomfortable with screencasting, and some are quite negative as a result. Frustration due to technological issues is a factor in students’ negative sentiments but it appears to be less important and should decline with experience. The most prominent negative factor reported by the students is the time required to complete the tasks. The reason the assignment takes a lot of time to complete is partly due to inexperience with the technology, but also that the students feel that screencasting places a high demand on the quality of the presentation. Many students report an improved sentiment of the assignments when their experience increases, but the improvement from having experience with one assignment to two, was not particularly significant. Given that most students were unfamiliar with the type of tasks, GeoGebra, screencasting software, video editing and presenting mathematics orally, the fact that so many students were positive and, in some cases, even enthusiastic, is considered a positive result. Better alignment between the assignments and the exam is likely an important factor in improving student perceptions of the assignments. In the present study only two (or three, counting A0) assignments were given due to practical reasons. One could expect that the experience gained from one or two assignments is not sufficient to bring the negatively contributing factors, such as inexperience with software and discomfort with hearing one’s own voice, to their lowest possible level, and therefore it is considered likely that student sentiments for these assignments could improve further.

Both DGS and screencasting are tools that have been shown to have significant potential in mathematics education (Chan & Leung, 2014; Galligan & Hobohm, 2018). This paper demonstrates that combining these two tools is a promising way to enhance students mathematical understanding and engagement, and that students value the increased emphasis on understanding. While many students may not initially appreciate the screencasting component, the learning benefits are believed to be strongly tied to the combined use of DGS and screencasting. Together they provide tools for effectively visualising mathematics and the necessary motivation to cognitively and actively engage with the material. It would be highly valuable to examine the long-term effects of such assignments on students’ conceptual understanding if they were used frequently over time, allowing students to become thoroughly familiar with them.

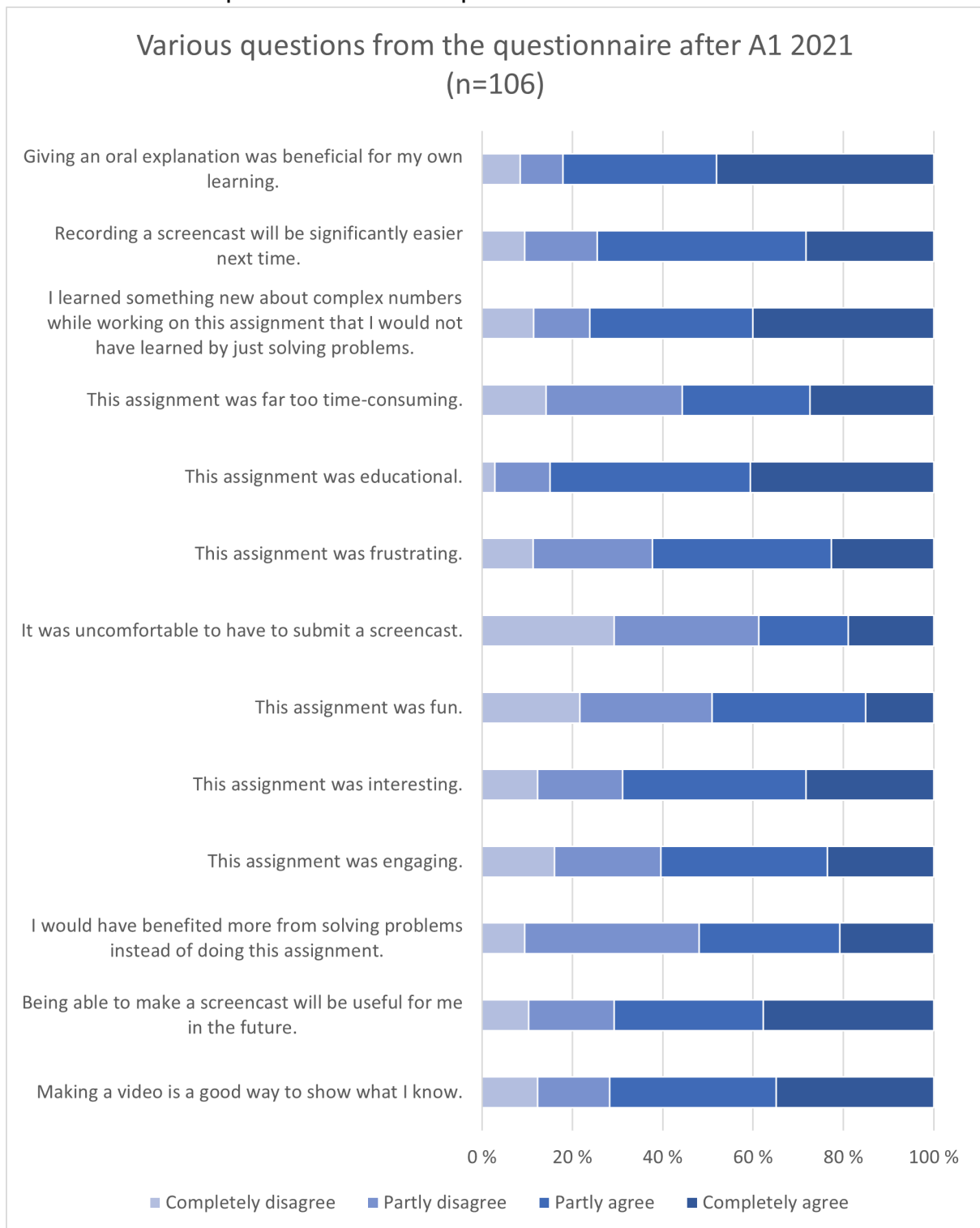
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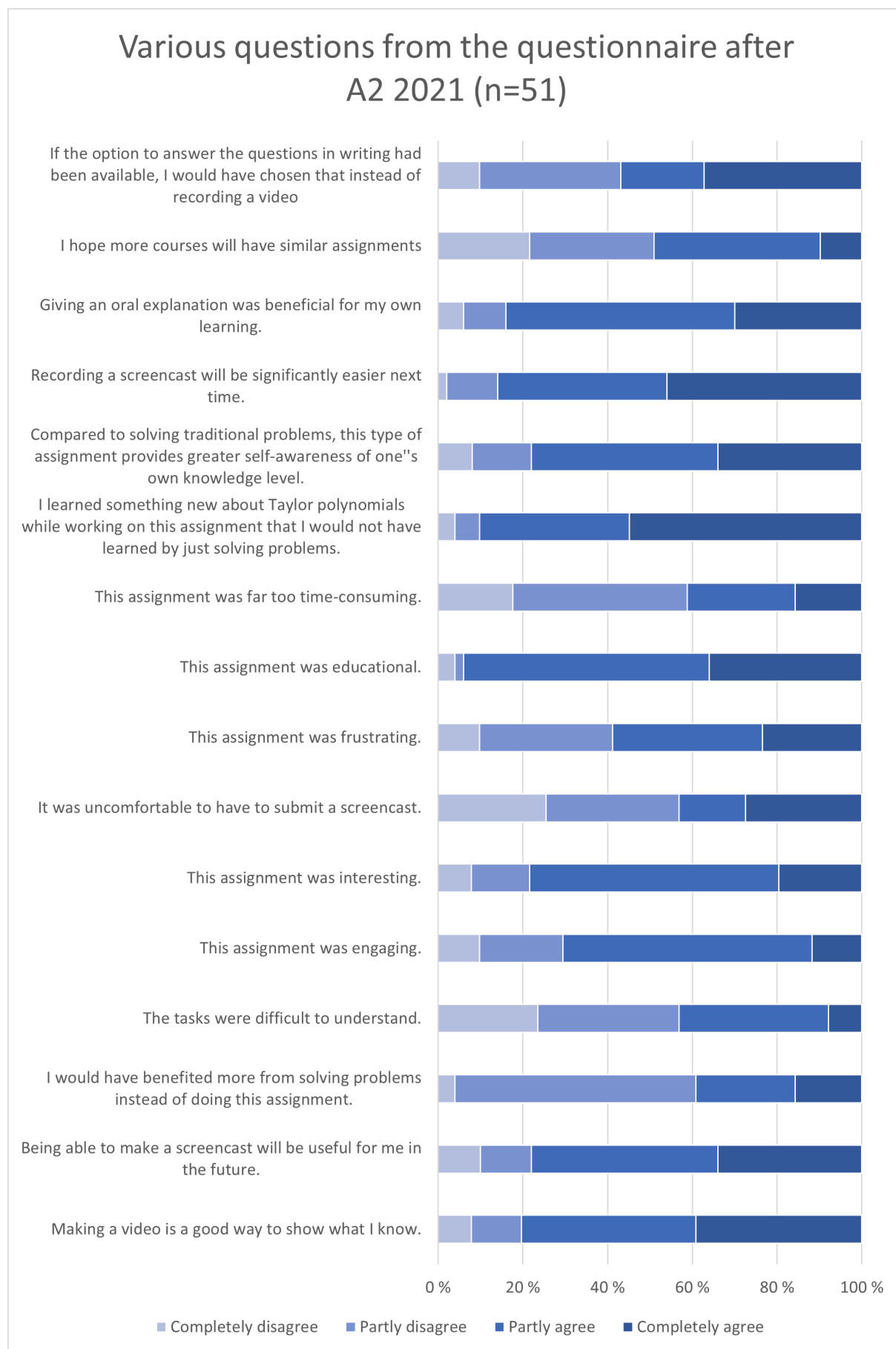
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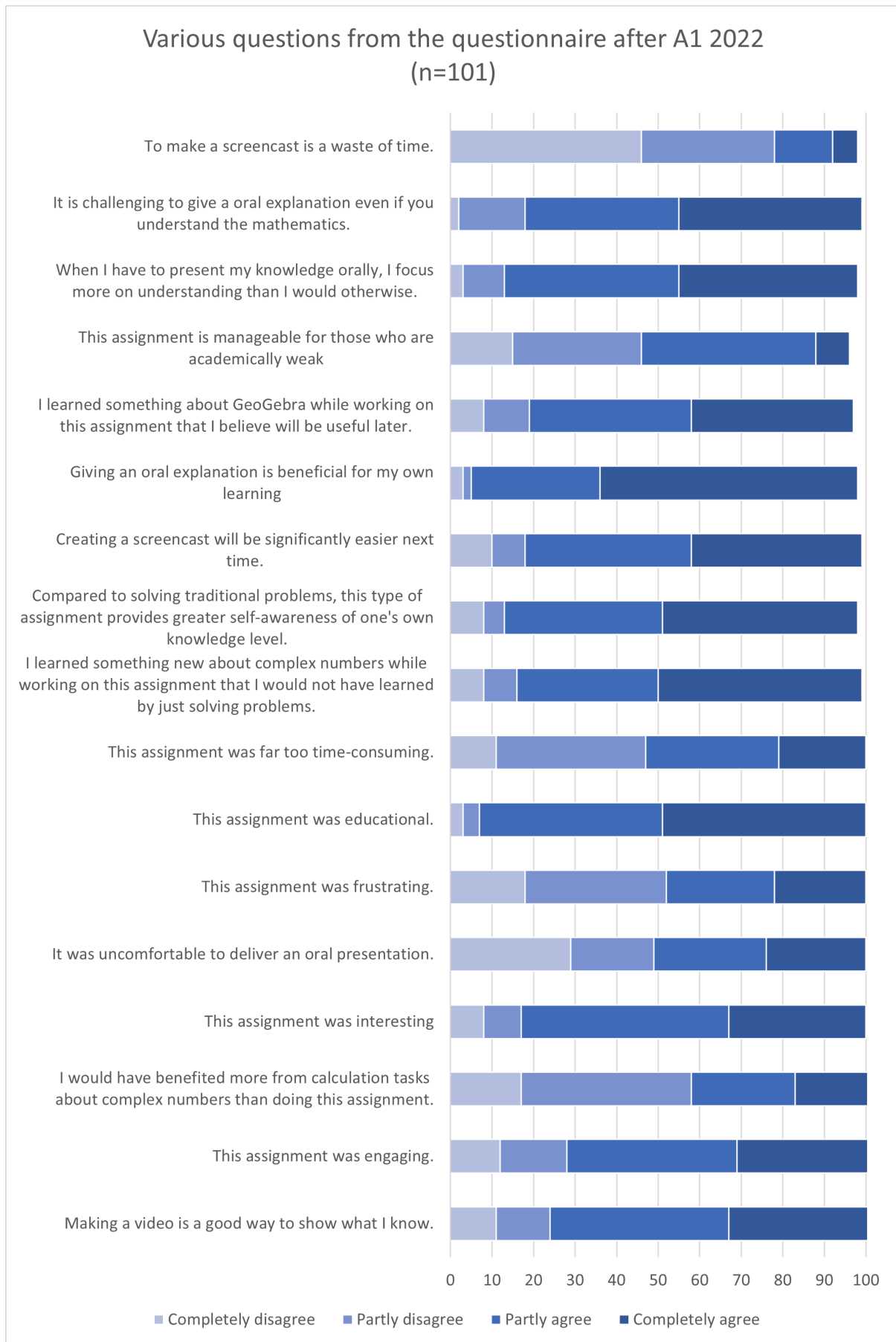
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5 Appendix

Various selected questions from the questionnaires







Various questions from the questionnaire after A2 2022 (n=39)

