LUMAT
International Journal on Math, Science and Technology Education

Research article

Students' Use of ChatGPT in an Algebra Class: A Case Study of Prompts and Attitudes

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Abstract: This case study explored how upper-secondary students (N=14) used ChatGPT in a Finnish 15-week long algebra course and their attitudes toward its use. The study collected students' ChatGPT prompts after a problem-solving session, in and out of class. Students' spontaneous prompts were analysed using a combined Technology-Mediated Learning (TML) and Self-Regulated Learning (SRL) framework. While most students reported in a post-questionnaire that they found ChatGPT easy to use and helpful in solving math problems, their spontaneous use of ChatGPT remained limited. Moreover, very few student prompts showed signs of goal-setting, reflection, or exploratory engagement. Our findings suggest that without explicit scaffolding, students rely on generative AI for quick answers rather than as a tool for learning and problem-solving.

Keywords: Generative AI, K-12 mathematics education, students' attitudes, algebra education

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1 Introduction

The applications of Artificial Intelligence (AI) in education have a long history. In a systematic overview of the research on AI applications in higher education from 2019 by Zawacki-Richter et al. the authors conclude that "it is still unclear for educators how to make pedagogical advantage of it [AI] on a broader scale, and how it can actually impact meaningfully on teaching and learning in higher education". However, the rapid introduction and wide-spread availability of a new class of generative AI tools, based on large language models (LLMs) such as GPT-4, has made it almost effortless for students with an internet connection to summarize documents, generate coherent text and solve complex mathematical problems. Before the introduction of generative AI, AI use in education was often very specialized and largely focused on tasks such as classifying and predicting using student data, so called Learning Analytics (Alfredo et al., 2024). Generative AI has also put into question how educators plan, execute and asses their own teaching (Bowen, 2024). One such change is the predicted death of the written essay as a favourite form of assessment in many school subjects (Uttich et al., 2025). While science and mathematics

Received 19 June 2025 / Accepted 17 November 2025 / Published 25 November 2025
Published by the University of Helsinki, Finland and LUMA Centre Finland.

may not see an equally rapid change, there are also indications that the traditional forms of assessment in STEM subjects may be in for an overhaul (Cooper, 2023; Yeadon et al., 2023). Here we should stress that there are some key differences in how generative AI is typically used in a mathematical versus a text-focused context. A typical math task is often convergent, rule-bound, resulting in one correct answer, while many text-based tasks (such as writing an essay) are divergent, audience- and style-dependent. This difference has direct implications on how generative AI is best used in different school subjects.

As most LLMs (ex. GPT-4) have been trained not only on pure text data, but also on books, articles and webpages containing mathematical symbols and calculations, an LLM is able to output (mostly) correct solutions to many pre-university mathematics problems (Frieder et al., 2023). It is perhaps even more promising from an educational perspective, is that students can interact with an LLM, not only obtain the correct solution to a mathematical problem, but also to get a step-by-step explanation, check a calculation, generate new examples, explore mathematical concepts and find examples of applications (Almarashdi et al., 2024). However, coupled with these promises are also fears that students' use of AI-tools could undermine the memorization of key mathematical facts, hinder the training of essential procedural skills and the formation of connections between mathematical concepts, things that are essential for developing mathematical expertise (Gilmore et al., 2018; Panaoura, 2025). These fears are reminiscent of similar worries expressed with the introduction of calculators equipped with computer algebra systems (CAS) in upper secondary school mathematics, where some researchers observed that CAS-calculators had a significant and non-intended influence on students' mathematical concept formation (Jankvist et al., 2019).

Considering the above-mentioned possibilities and challenges that generative AI could afford students in mathematics, it is important to study how students use generative AI in and out of class when given the opportunity. The number of studies focusing on the use of generative AI in mathematics teaching and learning is growing fast. In a recent scoping survey of ChatGPT in mathematics education (Pepin et al., 2025) the authors highlight AI:s potential for enhancing students' self-regulated learning and providing real-time feedback, but they also point to the risk of students becoming over-reliant on AI. To learn more about how students interact with ChatGPT while problem-solving or learning mathematics, one can study the prompts they write. (For brevity we will use the term "prompt" to denote one or more student inputs to ChatGPT connected to the same task or problem.) Will students only write prompts to get the correct answer to a homework problem, or will they, as AI-optimists hope, use generative AI as a personal tutor helping them explore a new mathematical concept or overcome an obstacle in solving a mathematical problem? Although important questions, we have not been able to identify any studies that look at the prompts upper-secondary students write while solving math problems. To address this research gap, we pose and seek to answer the following research question:

RQ1: How do upper-secondary math students interact with ChatGPT as seen through the prompts they write?

A follow-up question closely related to how students use AI in math, is if and how its use will affect students' motivation for learning mathematics? Put drastically: Why should I as a student put in the effort that is required to learn basic algebra skills when ChatGPT will be able to solve all my future math problems? Following these lines of thought we also pose a second related research question:

RQ2: What are students' attitudes towards using ChatGPT in math class?

We will return in more detail to the Finnish context of the study, but it should be mentioned already here that all upper-secondary students in Finland have access to a personal computer throughout their school day. While students mostly use their computer for reading textbooks, writing text, searching for information, and doing mathematical calculations (GeoGebra and Excel), they also have experience of using generative AI. However, no systematic studies have (yet) been done on how Finnish upper-secondary students use generative AI in mathematics and other school subjects.

2 Related research and theoretical framework

In education it has long been acknowledged that one-to-one tutoring is one of the most efficient ways to learn (Bloom, 1984). However, classroom reality often makes it hard to adapt the teaching to each individual student and provide the appropriate feedback at the appropriate time. It is in this context that the new generative AI-tools and LLMs have re-awakened the hope of (finally) making education more personalized and adaptive. While all the future implications of AI in education are unknown, AI's impact is almost certainly going to vary with subject area and with educational level. In the area of mathematics most research to date has focused on the use of LLMs (and specifically ChatGPT) in higher mathematics education (Biton & Segal, 2025; Ellis & Slade, 2023; Govender, 2023; Zhao et al., 2023). ChatGPT has been studied as a tool for planning teaching, generating tasks and problems, and assessing students' solutions (Arrington et al., 2025; Bhandari et al., 2024; Guttupalli, 2023; Pelton & Pelton, 2023). As any adoption of a new technology is closely connected to its capabilities, another active area of research has been on the mathematical capabilities of LLMs on standardized mathematics tests and word problems, showing that their performance is good and keeps on improving (Kaya & Yavuz, 2025; Korkmaz Guler et al., 2024; OpenAI et al., 2023).

In the present study, we focus on high school mathematics and students' use, both in and out of class, of ChatGPT in their mathematics course. As it has been much less common for high school students to be given access to, or be encouraged to use, generative AI in a regular mathematics class, much less is known about how students use these tools in mathematics and their attitudes towards their use. The research that has been done, applying both a student and a didactic perspective, has shown generative AI to be of a somewhat mixed blessing. While some studies indicate that students use of ChatGPT reduces stress and stimulates mathematical problem-solving abilities (Pavlova, 2024), as well as improves learning outcomes (Li et al., 2023), other studies show that students who have started to depend on ChatGPT for their course work show a reduced performance compared to students relying on teacher-led instruction (Dasari et al., 2024). Thus, as the results are mixed, most authors agree that more studies are needed to resolve the issue on how to best integrate generative AI in the mathematics classroom to promote student learning. So, what would constitute a pedagogically informed use of generative AI in a high school mathematics classroom? While there is no consensus, most AI-proponents agree that, at a minimum, they would like to see students move beyond a simple copying of a problem text to a prompt followed by the subsequent copying of the generated output. Using AI-tools to better understand a concept, explore an abstract idea, show a step-by-step solution or derivation, check a calculation, or suggest alternative ways to solve a problem, would by most educators be seen as a more active and purposeful use of generative AI.

Technology-mediated learning theory (*TML*) is a theorisation of situations where technology mediates learning (Bower, 2019). In the context of mathematics education, *TML* has a history that goes back to the introduction of graphics calculators and computers into the secondary school mathematics classroom. Then, as now, the hope was that the new technology would enhance students' learning and their active engagement with mathematical ideas (Goos et al., 2003). One of the key insights of *TML* is that technology is not just a tool, but that it also actively shapes and influences the learning process. For example, if a student uses ChatGPT to generate a detailed step-by-step solution to a problem, instead of solving it independently using pen and paper, then we can say that the technology has influenced how the student approaches the problem. Another fundamental idea of *TML* is that the agency resides with the student, not with the technology (Bower, 2019). It is the student that decides, within the limits placed by the student's prior knowledge and the capabilities of the technology, how they will utilize the technology. Thus, while the technology provides the tool, it is how the student engages with the tool that shapes the learning process and the outcomes. According to *TML* the student can view the technology as a master, a servant, or as a partner (Goos et al., 2003). For example, an uncritical over-reliance on the black-box output of ChatGPT would reflect a view of ChatGPT as a master, while an interactive and exploratory interaction would reflect a view of ChatGPT as more of a learning partner. While *TML* theory, to our knowledge, has not previously been applied to students' use of generative AI in mathematics, the *TML* framework has been used to analyse the development of AI literacy in higher education (Honigsberg et al., 2025) and to study the learning outcomes as they relate to university students' use of generative AI (Bai & Wang, 2025).

While *TML* is a framework for understanding the technology-student interaction and sees learning as a process shaped by the interplay of technology, learner characteristics and the instructional design, the student's internal goals, plans and motivations are less in focus. A theoretical framework that has been used to understand students' self-directed learning, is the theory of *Self-regulated learning* (*SRL*) (Zimmerman, 2002). Key concepts in *SRL* theory are goal setting, self-monitoring, and feedback-seeking, concepts that has also been used to describe students' self-regulated learning in environments with a prominent technological component (Persico & Steffens, 2017). A key finding of *SRL* research, relevant to students' use of generative AI, is that although the technology may provide opportunities for autonomy, students may frequently struggle with self-regulation in an open-ended technology-enhanced learning environment (Prasse et al., 2024). If we take ChatGPT as an example, students can either utilize ChatGPT to explore a concept or a problem, deepening their understanding, or they can ask ChatGPT for just the solution, which suggests a more superficial learning. While ChatGPT has feedback potential, un-prompted ChatGPT does not encourage students to reflect on their own thought processes and learning strategies. Central concepts of *SRL*, such as seeking task clarification and understanding, planning, selecting a strategy, asking for problem-solving assistance and self-monitoring, must be initiated by the student and, if a generative AI-tool is used, expressed through the prompts that the student writes. In a recent pilot study (Ng et al., 2024), researchers developed and tested a generative AI-based chatbot and a rule-based AI chatbot in a secondary science education setting. Both types of AI-bots were explicitly designed to try to encourage regular study habits and facilitate students self-regulated learning. One of the conclusions of this study is that ChatGPT can enhance students' science knowledge, motivation and self-regulated learning, however, a pedagogically informed pre-prompting of ChatGPT needs to be done to customize the interaction and the responses. These results are in line with a recent synthesis of 14 empirical studies on the role of AI in supporting university students self-regulated learning (Lan & Zhou, 2025). The research review highlights both AI's positive potential and the risks of reduced learner autonomy, feedback overload, and disengagement or confusion, calling for a balanced AI integration, harnessing generative AI's advantages without undermining student self-efficacy.

In our present study we are interested in how a group of high school students use and interact with ChatGPT in their mathematics studies. By using elements from both *TML* (how technology shapes and influences the learning process) and *SRL* (self-regulation in problem solving) as our theoretical lens, we want to study if ChatGPT affects how students approach mathematical problem solving. For example, if shown examples of a more effective prompting in mathematics, as introduced to the students in what we call *teacher-initiated ChatGPT-sessions* (see appendix B and C), and given the opportunity, will students ChatGPT prompts show signs of self-regulated learning? Will students' prompts reflect goal setting, strategic planning and feedback-seeking, or will they only contain a copy-paste of the problem text?

3 Materials and Methods

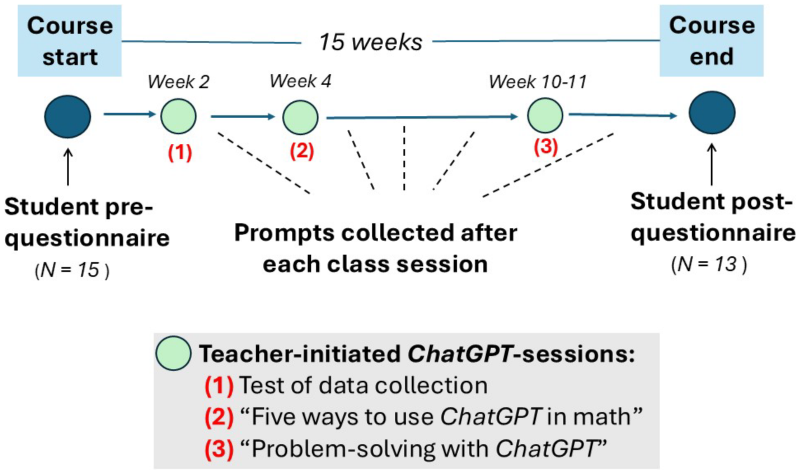
3.1 Context and educational setting

In Finland, general upper-secondary education (ages 16–19) is usually three years, but the duration can be flexible. General upper-secondary school prepares students for higher education, ending with a national Matriculation Examination. Students follow an individualized study plan, selecting courses across subjects. Mathematics courses are offered at two levels: Advanced syllabus (A-level) with 10 compulsory courses plus optional courses and Basic syllabus (B-level) with 6 compulsory courses plus optional courses (NCC, 2019). The current study was done in connection with the first compulsory mathematics course taken by students aiming for an A-level in mathematics. The course was a 15-week long basic algebra course, covering functions and equations, with an average of three sessions per week, each of length 75 minutes. At the start of the course 15 students registered and 14 students completed the whole course. During the first session students were informed by their teacher that they could participate in a trial on how to use ChatGPT in mathematics. It was stressed by the teacher that all participation was voluntary and that this would be an ordinary mathematics course: no exam questions or course grades were in any way connected to students' use or non-use of ChatGPT. All participating students were also presented with what would, and what would not, constitute an ethical and responsible use of ChatGPT during the course and that ChatGPT can make mistakes and that they therefore should remain critical of its output. The use of ChatGPT during the course was framed by the teacher as an opportunity for students to learn more about a useful technology. All 15 students agreed to participate in the study and gave their written consent to ensure that their ChatGPT prompts could be shared with both the teacher and researchers. During the course all students had at their disposal a personal computer. All computers had all the necessary software pre-installed and a free version of ChatGPT (GPT-4) was used throughout.

3.2 Data collection

The data collected in the study consisted of students' responses on a pre- and a post-questionnaire and the ChatGPT prompts written by the students in and out of class. The different data collection stages are illustrated in Figure 1. At the start of the course all students answered (in class) a pre-questionnaire (appendix A) regarding their previous experience with using generative AI. At the end of the course the students were given a post-questionnaire (appendix A) of their thoughts on using ChatGPT in the mathematics course. All students starting the course (N=15) answered the pre-questionnaire, while 13 students answered the post-questionnaire (one student elected not to complete the course).

Figure 1. The various data collection steps.



During the 15 week-long course there were three short (each 10-15 mins long) teacher-initiated ChatGPT sessions. The goal of these sessions was to both address any technical issues in collecting students' prompts and, more importantly, give students examples of how ChatGPT could be used in learning mathematics. The first such session (week 2) had students create a ChatGPT account, write a prompt to solve a simple mathematics problem from the course book and save the link to their ChatGPT conversation in an online Excel document. The primary function of this Excel document, which was shared with the teacher and the researchers, was to serve as an individual ongoing log where students could color problems according to how well they understood them as well as write comments regarding problems. After this initial session, students were told by the teacher that they could use ChatGPT as much, or as little, as they wanted to get help while solving problems. The only request by the teacher was that if they did use ChatGPT they should share the link to their ChatGPT conversation. The second teacher-initiated ChatGPT session (week 4) introduced students to five ways they could make better use of ChatGPT to learn mathematics. The teacher gave all students a text describing the five ways (appendix B), with examples to explore, as homework, with a reminder to share the link to their ChatGPT conversation when finished. After this session the students were again encouraged to use ChatGPT whenever they liked in the course. The third, and final, teacher-initiated ChatGPT-session (week 10-11) was focused on the use of ChatGPT in more extensive problem-solving (see appendix C). During week 10 the focus was on rational functions and students worked independently, while during week 11 the focus was on performing calculations with rational expressions and students worked in groups of 3 to 4. Again, students were reminded to share the link to their ChatGPT prompts. After this final teacher-initiated ChatGPT session, students were again encouraged to use ChatGPT whenever they liked or needed. To summarize, the intent of the second teacher-initiated ChatGPT-sessions was to provide students with scaffolding examples of how they could use ChatGPT to further their learning in mathematics. The intent of the third session was to study how students would use ChatGPT when working with more open-ended mathematics problems, as the exercises in their textbook were mostly of a closed character.

3.3 Data analysis

The Likert-scale items on the student pre- and post-questionnaire are summarized using descriptive statics. In the analysis of students' answers to the open questionnaire questions, questions 3, 4, 5 and 6 in the post-questionnaire (see Appendix A), we use a thematic analysis (Clark et al., 2021) to identify categories relevant to answering research question two (RQ2), regarding students attitudes towards using ChatGPT in the course.

To study how students interact with ChatGPT as seen through the prompts they write (RQ1), we analyze students' prompts through the lens of the *TML* and *SRL* frameworks. Our conceptual space, where each individual student's prompt can be seen as located, consists of four dimensions. The *TML*-framework's concepts of *Technology Dependence* (TD) and *Inquiry and Exploration* (IE) form the first two dimensions, while the *SRL*-framework's concepts of *Self-regulation and Feedback-seeking* (SR) and *Goal setting and Reflection* (GS) form the other two dimensions. A given student's ChatGPT prompt, as it relates to solving a specific problem or exploring a mathematical concept, can thus be thought of as a point in this four-dimensional space. However, to serve as a practical tool for analysis these four high-level concepts (dimensions) need to be interpreted within the context of a specific subject and a specific task. As an example, a student's ChatGPT prompt may show that they use ChatGPT to just get the final answer to a mathematical problem, supressing all intermediate steps and asking no follow-up questions. In a math context, this prompt would score high on the *Technology Dependence* (TD) dimension and low on all other three dimensions. As another example, a student's ChatGPT prompt may show them suggesting a solution strategy to a mathematical problem, receiving feedback, then refining their solution strategy based on the feedback. These signs of iteration, feedback-seeking and refinement in a prompt, would give it a high score on the *Self-Regulation and Feedback-Seeking* (SR) dimension. All four dimensions, and examples how they are made concrete in a mathematical context, are summarized in Table 1.

Table 1. The four dimensions derived from *SRL* and *TML* theory. Examples of how these dimensions relate to the prompts students write in a math context are also shown.

Dimension (code)	**ChatGPT use - math context**	**Example prompts**
Technology Dependence (TD)	Using ChatGPT only for minor checks (*low*) Full answer no engagement (*high*)	*"I got x=3 is this correct?"* (*low*) *"Solve* $x^2 - 5x + 6 = 0$" (*high*)
Inquiry and Exploration (IE)	No conceptual exploration (*low*) Engaged mathematical exploration (*high*)	*"Solve* $x^2 - 5x + 6 = 0$" (*low*) *"Can you solve* $x^2 - 5x + 6 = 0$ *using factoring and the quadratic formula? How do they compare?"* (*high*)
Self-Regulation and Feedback-Seeking (SR)	Directly accepts ChatGPT answer (*low*) Refines prompts and iterates (*high*)	*"Thanks for the answer"* (*low*) *"Can you explain the last step in more detail?"* (*high*)
Goal setting and Reflection (GS)	No explicit learning goal (*low*) Problem-solving linked to learning goals (*high*)	*"Solve this problem"* (*low*) *"I want to get better at solving these types of problems, can you quiz me with different problems?"* (*high*)

Our main goal in creating this coding scheme is to capture how students' ChatGPT prompts reflect how they engage with ChatGPT during problem-solving, from an uncritical over-reliance on the technology to a more strategic and reflective use. In our analysis we make a clear distinction between what we call students' *spontaneous prompts* and prompts directly written in response to the three teacher-initiated ChatGPT-sessions. We focus solely on students' spontaneous prompts, since the other type of prompts show (by design) very little variation. By focusing on students' spontaneous prompts, we address our first research question (RQ1).

Classifying spontaneous prompts as "high" or "low" on the four dimensions TD, IE, SR, and GS, enables us to distinguish between prompts that reflect a student's intention to engage more deeply with a mathematical concept or problem, using ChatGPT as a mediating tool. A prompt that reflects an intention to engage more deeply, we define as being of "higher quality". A ChatGPT prompt that scores high on *Inquiry and Exploration* (IE), *Self-Regulation and Feedback-Seeking* (SR) and *Goal setting and Reflection* (GS), but low on *Technology Dependence* (TD), would in our scheme be rated as a prompt of high quality. Regarding dimension TD it should be stressed that students who did not use ChatGPT at all during the course can also be said to display a low technology dependence. However, this will not show up in our results since there are no prompts to analyse; our focus is solely on prompt quality not student behaviour. In summary, a ChatGPT prompt of high quality reflects a deeper engagement with a mathematical problem and a view of the technological tool as, what *TML* call, a partner.

4 Results

4.1 Students' expectations and previous AI use

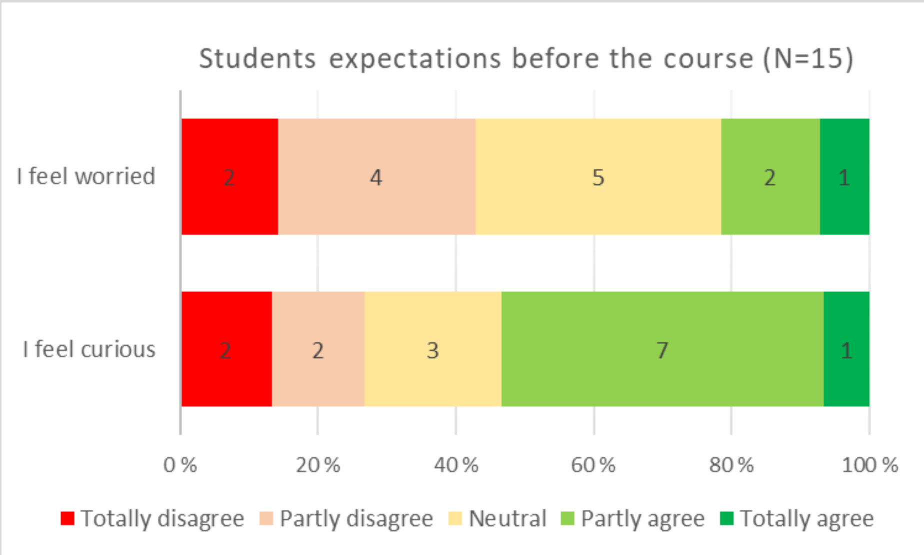
To provide a clearer view of the context of the study and of students' previous experiences with using AI, we conducted a pre-questionnaire. As can been seen from Table 2, most of the students (13 out of 15) that participated in our study had previous experience using some AI tool. While 10 of the students had experience of ChatGPT, the second most popular AI tool (six students) on the list was My AI on Snapchat (My AI, imbedded in the popular messaging app Snapchat, can be used to answer questions, offer advice on gifts, help plan trips, or give dinner advice). Only three students answered that they had previously used an AI tool in mathematics.

Table 2. Pre-questionnaire results: students' use of AI before the start of the course.

Question	**Response Options**	**Count (N=15)**	**(%)**
Have you used generative AI?	Yes	13	87%
	No	2	13%
Have you used AI in mathematics?	Yes	3	20%
	No	12	80%
What AI-tools have you used? Tools mentioned (#students)	ChatGPT (10), Snapchat AI (6), Copilot (3), Photomath (1)		

Before answering the pre-questionnaire questions the students had been informed by the teacher that the current mathematics course would have the same content and learning goals as previous years, however, the students would be given the opportunity to use ChatGPT in the course to solve problems and get additional help. Given this information students got to rate their sense of worry and curiosity with respect to the upcoming course. As can be seen in Figure 2, less than half of students felt worried about the prospect of using ChatGPT in the course, while a little over half of the students felt at least partly curious.

Figure 2. Students' expectations on the use of ChatGPT in the mathematics course

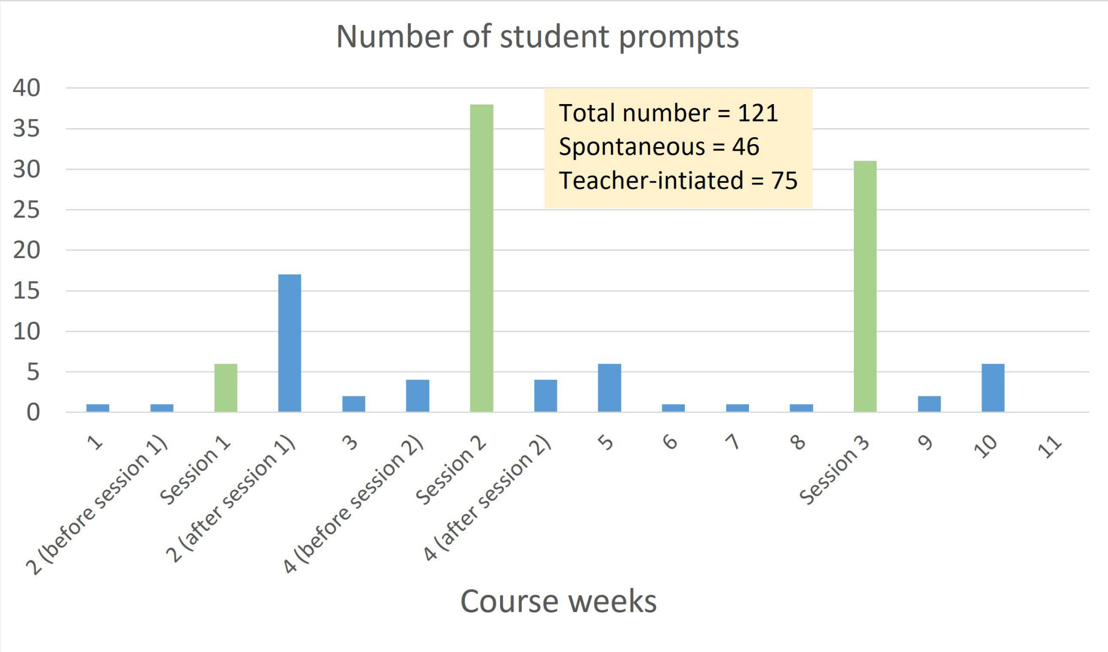


4.2 Teacher-initiated versus spontaneous prompts

During the course, students wrote and linked a total of 121 ChatGPT prompts. The number of prompts per student showed large variations, with some students being much more active in their reported ChatGPT use. In Figure 3, the number of prompts written by the students during the 15-week long course. As expected, the graph shows more prompts being shared by students in connection with the three teacher-initiated ChatGPT sessions. However, what is of more interest to us as researchers, is the number of what we call spontaneous prompts written by students. These prompts were not initiated by the teacher but written by the students during the math course to for example explore a new concept, solve a problem, or check a calculation that they had done. The number of spontaneous prompts were 46 (38 %). Again, different students showed different levels of ChatGPT use. Out of the 15 students in the course, 8 (53 %) shared at least one spontaneous ChatGPT conversation and 3 students (20 %) shared more than 5 (only 7 of these 8 students are included in the analysis because the links that one student shared could not be opened).

During certain weeks in the course no ChatGPT prompts were written and shared. Referring to the graph in Figure 3 one can observe a small rise in the number of spontaneous prompts following a teacher-initiated session. This positive trend, however, returns to the same low base-level after one to two weeks. As a side note regarding the mathematical content of the ChatGPT prompts, we were only able to identify one ChatGPT-generated mathematical error in the output from the 121 prompts written by the students. The students were thus not likely dissuaded from using ChatGPT due to lack of trust in its mathematical capabilities.

Figure 3. The number of prompts written by the students over the 15-week course. Out of the 15 weeks, 11 weeks where active class time. The number of student-generated prompts associated with the three teacher-initiated ChatGPT-sessions are large (green columns) compared with the number of spontaneous prompts (blue).



4.3 The quality of students' spontaneous ChatGPT prompts

As discussed in section 3.3 (Data Analysis), we consider students' ChatGPT prompts that are not only a copy-pasting of the original mathematics problem, but contains iterations and refinements, as being of higher quality. The ChatGPT conversation below is an example of an actual student prompt that was coded as high on TD, and low on IE, SR and GS:

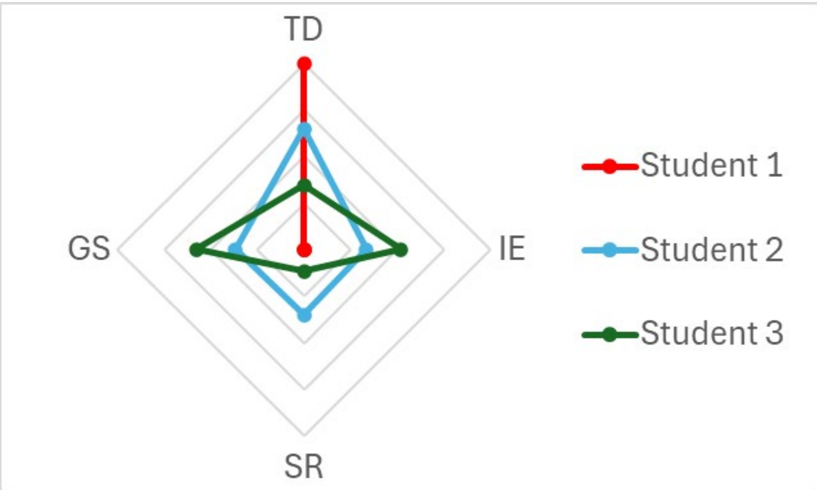
Problem: *Simplify to one rational expression:* $\frac{x-1}{x^2-9} - \frac{x}{x+3}$ *, where* $x \neq -3$ *and* $x \neq 3$ (X)
Student's ChatGPT conversation:
Can you simplify the following expression? (X)
[answer/output]

The student has copied the entire mathematical expression (X) as a prompt without any follow-up questions or further explorations. This example can be compared to another actual ChatGPT conversation that was as coded low on TD, moderately high on GS, and high on both IE and SR:

Problem: *The number x is equal to the inverse of its square. Find x.*
Student's ChatGPT conversation:
What is an inverse number?
[answer/output]
so the inverse of x is 1/x?
[answer/output]

In trying to solve the problem the student faces a new, unknown concept. Asking ChatGPT for a definition of what an inverse number is and getting an answer, the student then proceeds to give an example to seek feedback if they have understood the concept correctly. Figure 4 shows the average TD, IE, SR and GS scores of the ChatGPT prompts of three students in the course. Student 1 score high on TD and low on all other three dimensions, indicating that all seven spontaneous ChatGPT prompts of Student 1 are of low quality. They were all copy-paste versions of the problem text, with only small, insignificant alterations. This conversation profile can be compared with the ones of Student 2 and 3. Both Student 2 and Student 3 show a higher average score on the dimensions IE, SR and GS. The ChatGPT prompts of Student 2 and 3 are therefore considered to be of a higher quality.

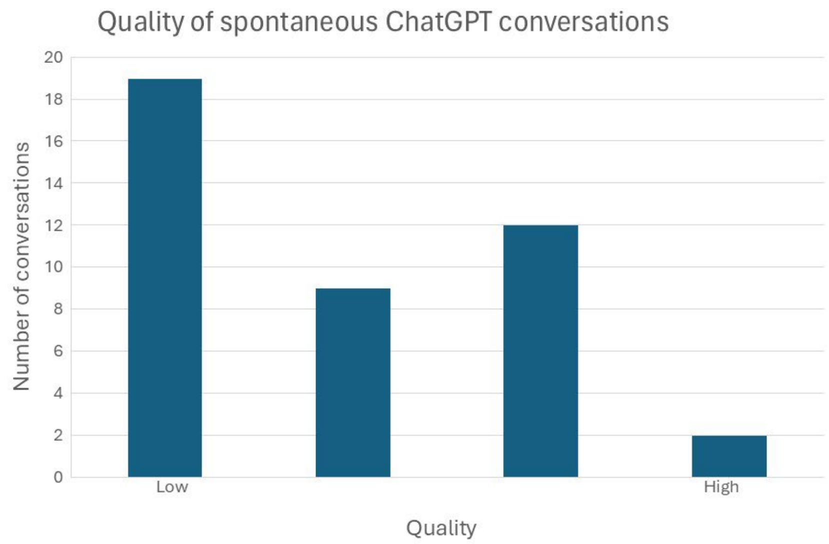
Figure 4. Examples of three different students' spontaneous ChatGPT prompts and their corresponding TD, IE, SR and GS scores. The scores shown are an average of all the spontaneous prompts submitted by the student (student 1: 7 prompts, student 2: 15 prompts and student 3: 13 prompts submitted).



It should be noted that the conversation profile of a given student in the course, as illustrated in Figure 4, remained relatively constant throughout the 15-week course. A student that started out by copy-pasting the text of a math problem directly into a prompt (low quality), ended the course with a similar prompt profile. Again, it should be stressed that the three teacher-initiated ChatGPT sessions, in week 2, week 4 and weeks 10–11, were specifically designed to give the students examples of more varied prompting in a mathematical context. Thus, the teacher-initiated sessions and the corresponding 75 student ChatGPT prompts, by design, showed a higher quality that, however, for most students were not later reflected in their spontaneous ChatGPT prompts. Figure 5 shows the quality of all spontaneous ChatGPT prompts submitted by the students during the course. As can be seen from the distribution, a little under half of all prompts were of a low quality and only two prompts were classified as being of highest quality. In between these two extremes, 21 prompts were high on one to two of the dimensions GS, IE and SR.

This quality distribution remained practically constant over the 15-week course, with no shift towards higher quality prompts over the course.

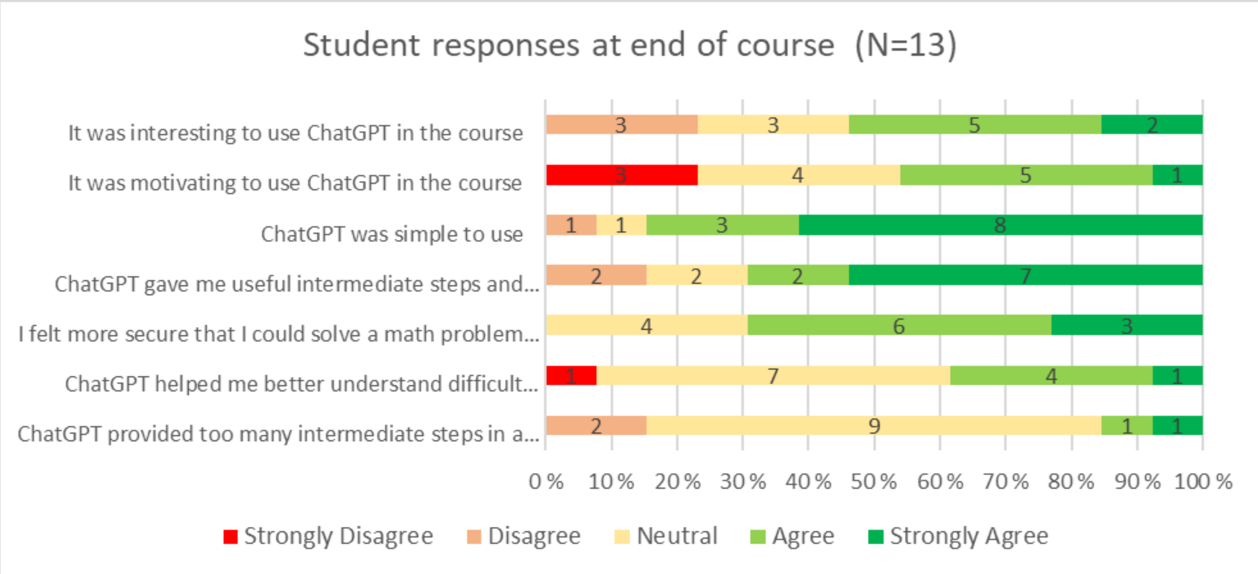
Figure 5. The rated quality of all 46 spontaneous ChatGPT prompts submitted by the students in the course.



4.4 Students' thoughts on the use of ChatGPT

The post-questionnaire (appendix A) was taken by the students at the end of the mathematics course. Out of the 14 students that completed the course, 13 answered the post-questionnaire. The students' response on the 7 initial Likert-scaled statements are shown in Figure 6. Approximately half of the students agreed or strongly agreed with the statements that it was interesting and motivating to use ChatGPT in the course, while 3 students strongly disagreed with statement that it had been motivating. A clear majority of students (11) agreed with the statement that ChatGPT was simple to use. Nine students agreed or strongly agreed with the statements that ChatGPT provided useful intermediate steps and explanations and that they felt more secure that they could solve a math problem when they could ask ChatGPT for help. Only two students agreed with the statement that ChatGPT provided too many intermediate steps when presenting a solution.

Figure 6. Students' opinions on the use of ChatGPT in the mathematics course (post-questionnaire).



Of the 13 students that answered the post-questionnaire, 11 answered that they had used ChatGPT also at times other than when the teacher had given an assignment or homework (i.e. the three teacher-initiated ChatGPT-sessions). When asked to give examples of how they had used ChatGPT in the mathematics course (Q3), 13 students responded by giving examples. The most reported use (6 students) was to check for errors in a calculation that they had done by hand, and the second most common use (4 students) was to get started on a problem, by for instance asking ChatGPT to show the first few steps in a solution. Two students reported that they had used ChatGPT to explain a specific word or concept. One student answered that they hadn't used ChatGPT and one student that they had only used it when explicitly instructed so by the teacher. When asked to give examples of when ChatGPT helped them to better understand a mathematics problem (Q4), 12 students answered the question. Three students said that they had asked for the intermediate steps of a solution, two students said they used ChatGPT to explain an unknown term (e.g. double root), one student said they had used ChatGPT to learn how to factorize and one to check a solution they had gotten. Three students gave no examples, and one said that they had not used ChatGPT at all (except when required). When asked if the use of ChatGPT during the course has affected their attitudes towards mathematics (Q5), 10 students answered no, while three students said that ChatGPT provided them with a sense that support was available if they didn't understand a problem or if they got stuck on a problem. Regarding if they thought that AI will change how students learn mathematics in the future (Q6), 10 students answered yes, while three answered that they didn't know. While seven of the students that answered yes to Q6 envisioned a positive future where AI would help students with solving problems, understanding difficult concepts and remove the need to ask the teacher all the time, three students expressed a mixed vision, acknowledging the positive applications, but also expressing a fear that AI may make you lazy and reduce your capability to think for yourself.

5 Discussion

The students that participated in our study were in their first year of upper-secondary school taking their first compulsory A-level mathematics course. Although our case study is limited by the relatively small sample size (N=15) and the Finnish educational context, there are some interesting observations and conclusions we can draw from our study. Most students (13 out of 15) had some previous experience of using generative AI prior to the class, but only three students had used generative AI in the context of mathematics. After the course, most students agreed with the statement that they had found ChatGPT easy to use and helpful. Despite this, the regular reminders, and the example use-cases given in connection to the three teacher-initiated interventions, the self-reported spontaneous use of ChatGPT by the students remained relatively low throughout the course. Although one potential explanation to this low number is that some students didn't share their ChatGPT prompts, neither the teacher nor the researchers found any indications of a large under-reporting of ChatGPT-use by the students. However, some under-reporting can be inferred from the discrepancy between the number of students that – in the post-questionnaire – answered that they had used ChatGPT outside the teacher-initiated sessions (11) and the number of students that shared links to spontaneous prompts (8). Another potential explanation for the low number of spontaneous student prompts could be that the three teacher-initiated ChatGPT-sessions, only three 15–20-minute-long sessions across the 15-week course, were insufficient to effect any significant change in students' prompting habits. After a short rise in number of prompts immediately following a teacher-initiated ChatGPT-session, the number of students prompts quickly returned to their pre-session levels and showed no significant improvement in quality. This suggests that giving students concrete examples of and some training is a more varied prompting in mathematics, is likely not enough. Explicit instruction plus scaffolding, coupled to assessment and feedback, may be required to promote a sustained change in students ChatGPT use. This confirms previous observations that students having access to a potentially useful tool doesn't by default translate into pedagogical value, unless students are scaffolded toward a more reflective and strategic use of the tool (Prasse et al., 2024). A deeper engagement with a tool, as noted by Ng et al. (2024), is as much the result of a deliberate pedagogical design as of prior knowledge and opportunity. Further, as emphasized by Lan & Zhou (2025), a balanced AI integration, utilizing its technological advantages, must be done without undermining students sense of self-efficacy. If students don't feel empowered by using a tool, they tend not to use it.

The number of spontaneous ChatGPT prompts produced by students, in and out of class, is not the only metric of interest. Most math teachers would also like to see a purposeful and goal-oriented use of any tool that is introduced into the classroom, not an over-reliance on the tool reminiscent of the introduction of CAS calculators into the mathematics classroom (Jankvist et al., 2019). To go beyond frequency of use and look at engagement quality, we look at students spontaneous ChatGPT prompts through the lens of *SRL* and *TML* theory. The teacher-initiated ChatGPT-sessions meant, by design, that students' prompts written in connection to these sessions showed a higher quality. However, this did not carry over into students' spontaneous ChatGPT prompts. The relatively low number of spontaneous high-quality ChatGPT prompts suggests that most students positioned the technological tool as a *servant* or *master*, rather than as a learning *partner* (Goos et al., 2003). Our results also supports the notion that while the technology was made available to students it was not internalized as a self-regulation tool, aligning with findings in the *SRL* literature that unreflective technology use rarely leads to goal-setting or feedback-seeking behaviour (Persico & Steffens, 2017). So, although ChatGPT provides ample opportunities for autonomy, students may struggle with self-regulation in an open-ended technology-enhanced learning environment (Prasse et al., 2024). To interact more deeply with ChatGPT, in a way that is more fruitful for mathematics learning, would require students to explore, ask for clarifications, plan, select a strategy, formulate prompts and self-monitor. These are all cognitively demanding tasks with a high intrinsic cognitive load (Ayres, 2006). In addition to the task-specific cognitive load, ChatGPT often also produces word-rich output, which as pointed out by Lan & Zhou (2025), could potentially cause a feedback overload resulting in student disengagement and confusion. So, while there is research that suggests that AI-tools can enhance higher-order thinking skills by structuring problem solving tasks (Kaya & Yavuz, 2025), acquiring the needed skills usually requires a focused effort over an extended period of time (Biton & Segal, 2025). In light of these observations, we return to our first research question on how upper-secondary math students interact with ChatGPT. To our knowledge, no previous studies have focused on student prompts in an upper-secondary mathematics context. In our study we see that students often only copy-paste the problem text, resulting in what we call low quality prompts. Short and focused teacher-initiated ChatGPT-sessions do not seem to be able to significantly change this pattern. Connecting to the findings discussed above, from generative AI-use in other subject areas and other contexts, our results indicate a low level of self-regulated, technology-mediated learning among the students in our study.

So, what did students think of using ChatGPT in their math course? Looking at the attitudes of the students on the use of ChatGPT in the course, we find a split between students that agreed with the statements that it was both interesting (7) and motivating (6) and a minority of students who strongly disagreed with it being motivating (3). Although we do not have data connecting a student's number of shared ChatGPT prompts and with their post-questionnaire answers, the above numbers agree with there being four students in the course responsible for most of the shared prompts. As for the small minority of students expressing a skeptical attitude towards AI-use, we can only speculate on the reason for their skepticism. A large-scale study done among university students on their attitudes towards ChatGPT has pointed to an intricate interplay between cognitive, affective, and behavioural components forming students attitudes toward the use of generative AI in education (Acosta-Enriquez et al., 2024). Self-reported curiosity, interest and motivation do not, however, automatically translate into ChatGPT prompts of a higher quality. Because the design of our study, where students' ChatGPT-use was optional and not connected to any course evaluation criteria, it is possible that students did not deem ChatGPT-use to be an integral part of succeeding in the math course. It is well known from previous research that established norms around how mathematics problems should be approached and solved in class, are difficult to shift (Liljedahl, 2016). Lacking a clear grading incentive, students revert to problem-solving methods that have worked for them in past math courses, resulting in a low use of any new tools.

6 Conclusions and future research

The use of generative AI in K–12 education is a controversial subject, with some researchers noting that the more we offload knowledge to external tools like AI, the less we exercise and develop critical cognitive capabilities (Oakley et al., 2025). However, few would argue that students' use of AI is a passing trend. Like it or not, most teachers acknowledge that students are probably using generative AI to solve home-work problems and write essays. As it is no longer possible to turn the AI-tide, we should learn more about how to foster a more meaningful engagement with any AI tools that is brought into the K-12 mathematics classroom. To do this without sacrificing the development of key mathematical skills, like students' number sense, arithmetic fluency, and problem-solving and spatial reasoning capabilities, is an area where much future research is needed. Specifically, we need to learn more about how to effectively design the student-AI-tool interaction to support both student learning and self-efficacy. As the details of any successful tool-design will be both subject and task specific, this will require active input from mathematics education research.

Research ethics

Author contributions

M.B.: conceptualization, writing—review and editing
K-E.B.: conceptualization, writing—review and editing
S.W.: conceptualization, data collection
S.F.: conceptualization, data collection.

All authors have agreed to the published version of the manuscript.

Artificial intelligence

ChatGPT (4.0) was used in the initial stages of planning the research project and when exploring potential theories that could be used in framing the research results. No AI was used in the analysis of the data or in producing the written version of the manuscript.

Funding

This is research was supported by grants from the Högskolestiftelsen i Österbotten.

Institutional review board statement

The study focuses on 15-year-old students and older. Students written consent was collected before the beginning of the study. No personal data was collected or stored. This study follows the guidelines on research ethics of The Finnish National Board on Research Integrity (TENK).

Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

Research data is digitally stored locally at Åbo Akademi University. Data is not publicly archived due to privacy or ethical restrictions.

Acknowledgements

This is research was supported by grants from the Högskolestiftelsen i Österbotten.

Conflicts of interest

The authors declare no conflicts of interest.

Appendix A

Translated student pre-questionnaire. All questions obligatory.

Question 1: Have you used generative AI previously (ex. ChatGPT or Copilot)?

(Yes/No)

Question 2: Have you used any AI-tool in mathematics (ex. Photomath, ChatGPT...)?

(Yes/No)

Question 3: What AI-tools have you used?

(Open answer)

Question 4: When you think about AI in school – how well do the following statements describe your opinion?

(Totally disagree = 1, partly disagree = 2, neutral = 3, partly agree = 4, totally agree = 5)

1.I feel curious

2.I feel worried

Translated student post-questionnaire. No questions obligatory.

Think about how you have used ChatGPT in the mathematics course.

Question 1: During the mathematics course I used ChatGPT to solve mathematics problems:

(Multiple choice)

only when the teacher told us that we should use it

also at other times than when the teacher told us to

Question 2: Indicate how much you agree with the following statements

(Totally disagree = 1, partly disagree = 2, neutral = 3, partly agree = 4, totally agree = 5)

1. It was interesting to use ChatGPT in the course
2. It was motivating to use ChatGPT in the course
3. ChatGPT was simple to use
4. ChatGPT gave me useful intermediate steps and explanations to math problems
5. I felt more secure that I could solve a math problem when I could ask ChatGPT for help
6. ChatGPT helped me better understand difficult mathematical concepts
7. ChatGPT provided too many intermediate steps in a solution

Question 3: Can you give some examples of how you used ChatGPT in the mathematics course?

(Open answer)

Question 4: Can you give an example where ChatGPT helped you to better understand a mathematics problem?

(Open answer)

Question 5: Has the use of ChatGPT affected your attitude towards mathematics?

(Open answer)

Question 6: Do you think that AI, for example ChatGPT, will affect how students learn mathematics in the future? If yes, how?

(Open answer)

Appendix B

The teacher-initiated ChatGPT-session in week 4 (*Five ways to use ChatGPT in math*). The five use cases (step-by-step explanations, applications, other examples, explore a concept and check a calculation) were chosen to give students examples of how they could use ChatGPT more effectively in math (Almarashdi et al., 2024) . The text below was given to students as a homework:

ChatGPT AS A HELP TO SOLVE MATHEMATICS PROBLEMS

Here are some ways you can use ChatGPT:

1. To **solve a problem step-by-step**. Why? Learn the intermediate steps in a solution.
   Example: Try writing the following prompt:

   Solve the following equation for x stepwise: $3x + 5 = 17$

2. To give **practical examples** how the mathematics that you are learning can be applied. Why? Learn how the mathematics you are learning can be applied.
   Example: Try writing the following prompt:

   Can you give a simple, practical example where I need to use a quadratic equation?

3. Suggest **other ways to solve a problem**. Why? Realize that often there are more ways than one to arrive at a solution and that the more methods you can master the better problem-solver you will become!
   Example: Try writing the following prompt:

   Can you show another way to solve the quadratic equation $x^2 - 4x - 12 = 0$ than using the root formula?

4. **Explain a concept or calculational procedure**. Why? You are not satisfied with the explanations and examples given in the book and would have more ways to understand a concept or calculation.
   Example: Try writing the following prompt:

   Give three examples how you can use the difference of two squares in mathematics.

5. **Check the intermediate steps in a solution** you have arrived at. Why? Learn how to error check your own mathematical solutions.
   Example: Try writing the following prompt:

   I have solved an equation for x and obtained the following intermediate steps: $5x - 8 = 12$, $5x = 12 - 8$, $5x = 4$, $x = 4/5$. Are any of the intermediate steps wrong?

Appendix C

The teacher-initiated ChatGPT-session in week 10 (*Problem solving and ChatGPT- part 1-individual assignment*) and week 11 (*Problem solving and ChatGPT-part 2-group assignment*). The problems were designed give students experience with using ChatGPT for exploratory problem-solving. The problem text below was given to all students as an assignment:

ChatGPT AS A HELP IN PROBLEM-SOLVING

Part 1. Explore the properties of a polynomial function

Ask ChatGPT to generate a polynomial function that fulfills certain criteria. You can choose which criteria you want the function to fulfill. The criteria can for instance be degree, zeros, number of roots, intersection with y-axis, that the function should pass through a certain point, or that the function should have positive function values in certain intervals.

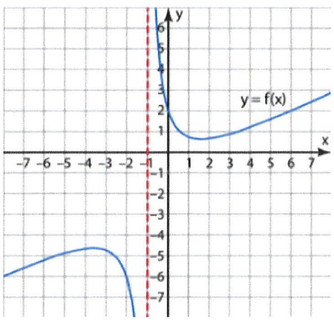
Part 2. Problem-solving in a group using ChatGPT as a possible (but not obligatory) tool

Problem 1

a) Generate an expression for a function that has roots at $x = 1$ and $x = 3$ and that has an asymptote at $x = -1$.
b) The intersection of the graph with the y-axis should be in the point (0,5).

Problem 2

In the figure is presented the graph $y = f(x)$ of the function $f(x) = \frac{ax^2 + bx + c}{2x + d}$ where the coefficients a, b, c and d are whole numbers. Determine from the graph the values of the coefficients and explain in words how you arrived at the solution [SE V2019]*



**The problem was from the mathematics matriculation exam (A-level), spring 2019*

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