Engineering students' engagement with resources in an online learning environment

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In this paper, we investigate how undergraduate engineering students interact with an online learning environment provided to them in a Calculus course. The constituent resources of this environment include tutorial videos, textbook and MyMathLab – an online interactive system for mathematics. A qualitative case study involving a small group of students has been conducted. We investigated which resources these students used and the manner in which they incorporated these resources in their online mathematical work.

Keywords: Students' interactions with resources, the role of digital and other resources in university mathematics education, mathematics for engineers.

INTRODUCTION

In recent years, digital resources are increasingly used for teaching and learning of mathematics (Borba et al., 2016; Pepin, Choppin, Ruthven, & Sinclair, 2017). The presence of wide range of digital resources in terms of their functionalities allows various possibilities of creating digital environments for students to learn mathematics. Each digital environment might afford unique interactive and learning opportunities; therefore, empirical research closely looking at students' engagement and the opportunities for their learning in such environments is well needed. This study deals with one digital learning environment provided to undergraduate engineering students for practicing mathematics. The aim is to explore students' interactions with the constituent resources of this environment to elucidate the learning opportunities in this environment.

Adler (2000) introduced the term *resource* to embrace several agents such as physical, human and cultural tools and aids intervening in a teacher's activity. In this paper, however, we distinguish between digital and classical resources and focus on students' work with resources. The use of digital resources is relevant in the context of engineering mathematics in the sense that engineers during their professional activities rely on technology for solving mathematical tasks (van der Wal, Bakker, & Drijvers, 2017). The framework for mathematics curricula in engineering education (Alpers et al., 2013) recommends the use of technology aimed at fostering engineering students' mathematical competencies. In the next section, we present the theoretical framework, and the subsequent section contains introduction to the constituent resources of the online learning environment.

THEORETICAL PERSPECTIVE

In order to study students' interactions with the resources, we employ the *documentational approach to didactics* (Gueudet, Pepin, & Trouche, 2012; Gueudet & Trouche, 2009) which is grounded on Rabardel's work (Rabardel, 2002) and enlarges the instrumental approach (Trouche, 2004) in mathematics education. One important distinction between the two approaches lies in the extension of the concept of *artefact*, in the former approach, to *resource* which allows considering wider set of materials intervening in the teachers' and students' activities. A resource can be conceptualised "as both noun and verb, as both object and action that we draw on in our various practices (Adler, 2000, p. 207)". Thus, the approach has the potential to take in consideration material, human and cultural resources such as language, time, mathematics teachers, etc. Moreover, a resource is never isolated but belongs to the wider set of resources (Gueudet & Trouche, 2009).

While one focus of this approach is on the teacher's work with the resources, the study of students' use of resources can provide the overview of their actual use (Gueudet & Pepin, 2016). Also, this approach has the potential to provide rich analyses if used to evaluate students' work in terms of interactions with different resource systems (Trouche & Pepin, 2014) or with a particular resource (Aldon, 2010). We will employ this approach to analyse how students interact with available resources.

In particular, we analyse students' techniques when working digitally in mathematics (Artigue, 2002). A technique is perceived as "a manner of solving a task (Artigue, 2002, p. 248)". While students work on mathematical tasks in a digital environment, they might adopt paper and pencil based techniques or instrumented techniques. The obvious and easily observable objective of each technique is to reach the goal of the activity i.e. to produce the results whereas the contribution of a technique to the learning of involved mathematical concepts might not be easily recognisable. The former corresponds to pragmatic value while the latter corresponds to epistemological value liked to each technique.

We seek to explore the kind of techniques implemented by the students in the digital environment to make sense of how students interact with this environment while working on mathematical tasks. Furthermore, realisation of the values attached to the students' instrumented techniques will also help to understand the role of digital resources in their learning (Guin, Ruthven, & Trouche, 2005). There are several resources involved in present situation, therefore, we confine to the general features of corresponding techniques in the present paper. By this, we mean to consider students' general organisation of digital work with several resources related to all contents in a Calculus course. We ask the following question: How do engineering students incorporate resources during their work in an online learning environment?

THE SETTING

This study took place in a Norwegian public university during the spring of 2017. Undergraduate students enrolled in electronics engineering program participated in this study. In their Calculus course, students were offered an online learning environment such that they could work remotely by interacting with the provided resources. These resources were made available to them electronically to work and proceed through the course. There were no mandatory lectures, and they could access the lecturer in the case they needed additional support. The final examination was also in digital format where the students were allowed the access to tools and aids.

The resource system comprised MyMathLab environment, tutorial videos coupled with the notes, and the textbook. The students' homework and the formative assessments were administered online through MyMathLab system. MyMathLab is an interactive learning system for practicing mathematics online (figure 1). While this system provides an online platform for homework and assessments, it also facilitates students in solving the tasks by providing help and feedback. Students can seek help through utilising "help me solve this" or "view an example" functions in the system. The former lets the student solve a similar task by guiding on each step whereas the latter shows a similar worked-example. The interactive nature of MyMathLab system allows considering it as a resource which can potentially influence students' activity in this course.

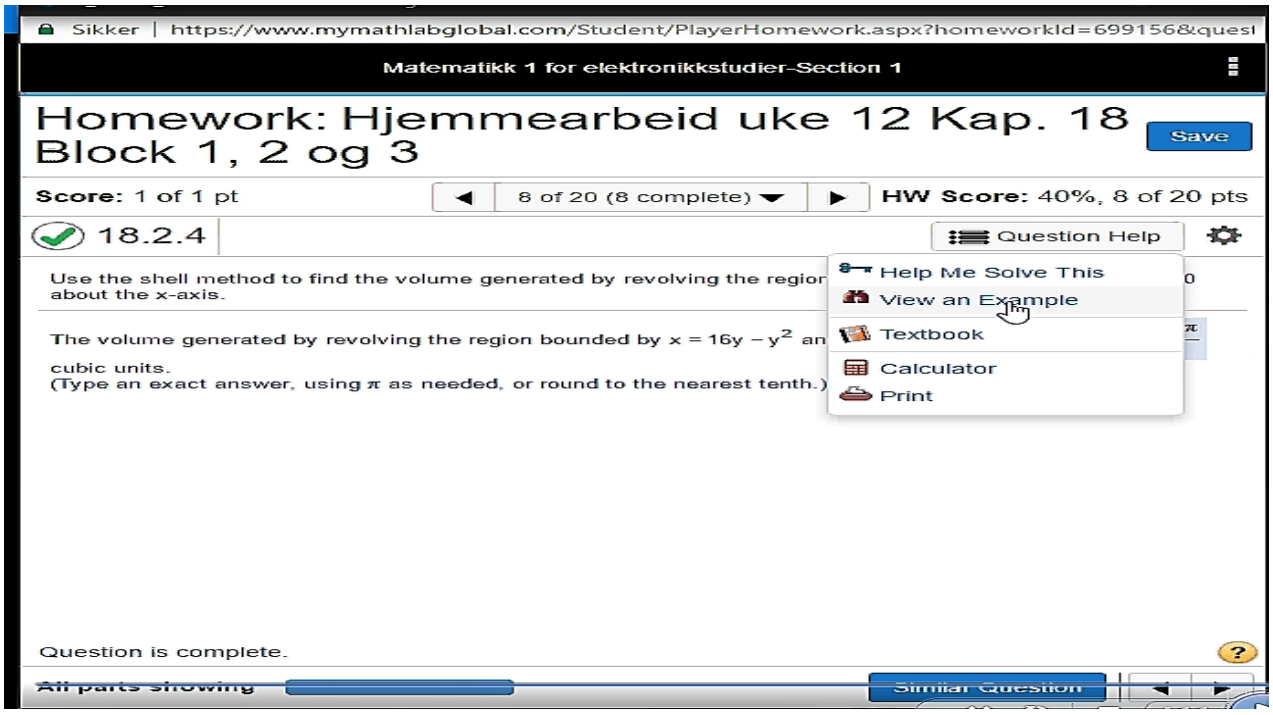

Figure 1. Interface of MyMathLab environment.

The tutorial videos are created by the lecturer, and recorded by using a document camera. Each video deals with a specific section in the book and is named

accordingly. In these videos, the lecturer explained the topics in the book and worked through the relevant examples occasionally. The notes pertaining to the video tutorials were available online. The length of these videos varies depending on nature of the concerned topics. The tutorial videos replaced lectures and it was expected that students would watch the videos to learn mathematical topics. The textbook served as the central resource in the sense that MyMathLab and tutorial videos were based on contents in the book.

In this course, a compulsory task was the group project in which students were required to prepare a question bank related to integration. That question bank was needed to be programmed in the STACK environment, a computer aided assessment platform. Maxima is the programming language used in the STACK, thus they were required to learn Maxima to complete the project. The intention was to make students familiar with programming language and its use in mathematics.

RESEARCH DESIGN AND METHODS

The case study research design (Yin, 2013) has been followed in this study. A group of three students has been observed over the semester. The methods used to generate data include group observations, semi-structured interviews, individual weekly journals and field notes. Using multiple methods for data collection contributed to triangulation of data.

In order to be able to observe participants' activity, we requested them to work at campus each week for which they agreed. During these sessions, they worked on their routine work including homework and assessments. Video recordings of their group work accompanied with the screen recordings to follow the activity on their computer screens have been collected. Screen recordings of their individual work external to these group sessions have also been collected. Furthermore, weekly journals containing self-reports about their use of resources were included to get the detailed overview. The journal was provided to participants in tabular format which they filled and submitted electronically each week. In the journal, they were asked to specify the resources they used and state how the use of a particular resource helped them in their work each week. The semi-structured interviews were held occasionally to understand the emerging patterns in their use of resources. During the group work sessions, participants communicated in their native language whereas the interviews were held in English. Both the group sessions and the interviews were transcribed.

We analyse participants' weekly journals, a semi-structured interview in the middle of the semester, screen recordings, and the field notes for reporting on students' use of resources in their work. This interview is being counted on because the participants were inquired about the general manner in which they used the resources. The observations, screen recordings and the field notes are being counted on while identifying participants' techniques during their work.

ANALYSIS

Participants' weekly self-reports about use of resources

Table 1 presents the overview of participants' use of several resources as they reported in their journals. The manner in which they used them in their work and their evaluations of resources have been extracted from their journal inscriptions.

Resource used	How they incorporated resources in their work	Comments about resources (if any)
Tutorial videos	Watched to get information to complete homework	Easy to understand through videos
MatRIC videos	Skimmed through the video at amplified speed	
Own note	Used the already solved similar problems in the notes, to recall the problems (methods for solution)	
Textbook	Read through the book, found formulas to work on homework, got questions from book (during project)	
Maxima	Programmed tasks in Maxima for the project, used while doing homework, solved tasks using Maxima	Programming in Maxima is hard but when it is done, all the problems are easy to solve
WolframAlpha	Used as a shortcut to get answers, compared answers obtained from Maxima, got help with solving difficult tasks	Easier to use than Maxima, Faster than using calculator, useful when the answer is in the form of expression instead of numbers
MyMathLab	Worked on homework, learnt specific topic, solved some questions with higher difficulty	Powerful tool, easier to get help and information online
Internet		
Lecturer's notes		Tailored" for the tasks at hand, the most relevant piece of information
Youtube vidoes	Watched Maxima tutorials	
Mathway and other online calulators	Solved questions	Severely increase the probability to get the correct answer, and therefore the overall score.
STACKS	Made some questions in STACKS	

Table 1: Overview of participants' use of resources.

The three participants, Tor, Per and Jan, used MyMathLab almost every week because homework and assessments were required to be done in this system. As regards the textbook, Tor did not report the textbook in the journals rather he used the lecturer's notes. While in Per and Jan's weekly reports, they pointed out few ways in which they used the textbook on different occasions. The textbook served as a source of getting questions, checking answers to those questions, getting help with formulas, and going through examples in the book. During their project work, they consulted the book to take questions and subsequently checked the answers for those questions.

The tutorial videos were reported to be used by Jan and Per during their work. Jan occasionally watched the videos and when specifying about the kind of help, he used the word *understand* linked with this resource such as "to try to understand how to calculate…" and "to understand the calculation behind the math". Per has also mentioned the use of videos and commented, "I easily understand it when someone explains me the way of solving a problem". Tor did not mention any tutorial video provided by the lecturer, however he watched few videos on other platforms, MatRIC TV (an online resource containing videos aiming to support students in their transition from high school to university) and YouTube, once for getting introduction to *partial integration* and at another occasion to learn Maxima – the programming language.

It can be seen that participants used some other resources in their work such as online calculators, WolframAlpha, Maxima and internet (cf. Table 1). Tor named several online calculators including Mathway (https://www.mathway.com) and WolframAlpha (https://www.wolframalpha.com) to solve the tasks and to compare the answers they got in Maxima while working on the project. He mentioned that he used online calculators for saving time, however, he wrote, "I did not learn anything doing this, but it severely increases the probability to get the correct answer, and therefore the overall score". Wolfram Alpha has also been used by Per and Jan in order to verify whether the answers they got were correct. While working on the project, they picked some questions from the book and programmed in Maxima. To check the answers to those questions, they used WolframAlpha.

After completing the group project that involved learning Maxima, this programming language became an important resource for them to solve tasks in homework and assessments. Both Per and Jan began making programs for solving each task to liberate themselves from calculations. Per inscribed in a weekly journal, "(I) used Maxima to make a program to solve the problems in an easy way. This is hard to make, but when it is done, all the problems are easy to solve". Tor did not seem to use Maxima a lot, he spent some time on learning how to use Maxima for solving tasks in one week, and then spending some more time in the next week, he rather chose to focus on MyMathLab. He inscribed that, "it's (MyMathLab) a more powerful tool and it's easier to attain help and information online".

In response to a question about using videos in a semi-structured interview, Per explained his way of working on homework using the provided resources.

Per: These topics I think are quite hard to learn all by yourself. When I get a new topic, I first try to solve it myself, if I can't do that I try to look at the examples in MyMathLab… and if I don't completely understand the examples I take a look at Olav's (lecturer) video…mainly the examples' videos because then I get to see the practical kind of way to do..to solve questions.

Int: How would you rank the provided resources? Which one do you first consult with?

Per: First, I will try to do it myself because then I think I… remember and learn it the best because then I have to think and ….and if I can't do it that way…then I will try to look at example just to get a few hints. If that does not work then I watch the videos because I can't look at the notes (provided by the lecturer)…I have to get explanation of what he is doing step by step.

Tor's response was somewhat similar as he replied:

Int: Did you use any video while working on last week's homework?

Tor: No, I think MyMathLab seemed sufficient so far.

Int: Ok. So which resource did you use for getting introduction to the new topic?

Tor: I tried first MyMathLab but it went fine so I just carried on. …I check the notes and watch the videos if I get stuck..

Int: So, you turn to the videos when you get stuck.

Tor: When it is a new topic, then I just skim through his notes, but since we have integration from a couple of weeks now, I am pretty confident and go straight with it.

While Jan responded to the same question as follows.

Jan: I did not watch that many videos. I mostly use MyMathLab and just see the examples…and if I can't get it from there then I go to…to the book because it is faster… and eventually go to the videos if I do not get constructive help from there.

The participants preferred MyMathLab during their work for being the source of quick and most relevant help in comparison to the other available resources. This approach of working on the tasks saved them time and effort to search for the required piece of information from other resources such as the videos and the textbook. However, the use of MyMathLab can be considered more pragmatic as both Per and Jan mentioned that the kind of help they get from MyMathLab is in the form of examples which contributes more towards producing the results.

Another approach was to watch the videos when the help from MyMathLab was not *sufficient* as evident through participants' responses in the interview. The use of videos has not been preferred much but participants reported that they consulted the videos when they needed to *understand* something. As discussed earlier, the help and feedback in MyMathLab concern the task only as it offers the formula and solution-steps for the task. They might have needed to consult the videos to learn the concepts involved in those tasks in case when just knowing the solution steps in a question did not work. In the journal data, Jan and Per wrote that they used the videos to *understand* thus it indicates the epistemic value linked to usage of videos.

Observing participants' activity helped in finding that the use of different resources affected their manner of working on tasks i.e. techniques. We seek to categorise the participants' techniques pertaining to different resources they used, and by considering their motives behind use of each resource helped in recognising the pragmatic and epistemic value of their techniques. It is found that they increasingly used the digital tools to solve the tasks in MyMathLab environment with the progression in the course. This led to the use of more instrumented techniques instead of paper and pencil techniques promoted in the lecturer's videos and through MyMathLab. For instance, Tor mentioned in his weekly journals and it is observed in the screen recordings of his individual work that he used several calculators to work on homework as well as assessments. The participants themselves perceived this technique of using online calculators to solve the task as pragmatic.

Two of the participants used Maxima in their work as evident from journals and could be seen through the screen recordings of their work. They wanted to be pragmatic in order to make their future work easier. Making programs for each task for the first time can not be considered as merely pragmatic as Per mentioned that he found it hard. The difficulty in making programs may be linked to their knowledge of programming in order to code mathematical tasks. However, the extent to which it contributes epistemically in learning mathematics is not covered in present paper.

DISCUSSION AND CONCLUSION

In this study, we observed how a small group of three students interacted with the resources when provided with an online learning environment in their Calculus course. The environment allowed self-regulated learning and students could work remotely on their homework and assessments. To make sense of the opportunities for students' learning with resources in this environment, we explored their manner of incorporating the resources in general organisation of their digital work. Furthermore, we discussed the epistemic and pragmatic potential of participants' techniques.

In terms of resource usage and the corresponding techniques, participants opted for the resources and the techniques which were pragmatic in terms of producing results for the assigned tasks. Pragmatic techniques involved the use of online calculators,

using help in the MyMathLab to produce the results for tasks. Watching videos for learning mathematical concepts seemed to be time consuming and hence not preferred much. Participants appropriated the programming language to work on the tasks with the motive to be more pragmatic and produce results easily in their work. An important factor which is likely to cause the preference for more pragmatic instrumented techniques was the online final examination where they could use the resources. As for students, it is quite important to prepare according to the examination to be able to score better.

This case study provides an example of a self-regulated learning environment created for students to work independently. Our findings suggest some general prospects which are worth paying attention when assigning online homework to students. Combination of an online homework with online examination is likely to cause students to use unexpected use of resources and techniques, for instance, online calculators and solution tools in the present case. This observation also relates to the nature of tasks posed in an online homework environment. Variety in the nature of tasks, such as open-ended tasks, may lead students to interact with resources epistemically.

REFERENCES

Adler, J. (2000). Conceptualising resources as a theme for teacher education. *Journal of Mathematics Teacher Education, 3*(3), 205-224.

Aldon, G. (2010). Handheld calculators between instrument and document. *ZDM, 42*(7), 733-745.

Artigue, M. (2002). Learning mathematics in a CAS environment: The genesis of a reflection about instrumentation and the dialectics between technical and conceptual work. *International Journal of Computers for mathematical learning, 7*(3), 245-274.

Borba, M. C., Askar, P., Engelbrecht, J., Gadanidis, G., Llinares, S., & Aguilar, M. S. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM, 48*(5), 589-610.

Gueudet, G., & Pepin, B. (2016). Students' work in mathematics and resources mediation at university. In E. Nardi, C. Winsløw, & T. Hausberger (Eds.), *Proceedings of the First Conference of the International Network for Didactic Research in University Mathematics (INDRUM 2016, 31 March-2 April 2016)* (pp. 444-453). Montpellier, France: University of Montpellier and INDRUM.

Gueudet, G., Pepin, B., & Trouche, L. (Eds.). (2012). *From text to 'lived' resources: Mathematics curriculum material and teacher development*. New York: Springer

Gueudet, G., & Trouche, L. (2009). Towards new documentation systems for mathematics teachers? *Educational Studies in Mathematics, 71*(3), 199-218.

Guin, D., Ruthven, K., & Trouche, L. (Eds.). (2005). *The didactical challenge of symbolic calculators: Turning a computational device into a mathematical instrument*. New York: Springer

Pepin, B., Choppin, J., Ruthven, K., & Sinclair, N. (2017). Digital curriculum resources in mathematics education: foundations for change. *ZDM, 49*(5), 645-661.

Rabardel, P. (2002). People and Technology: A cognitive approach to contemporary instruments (translation of Les Hommes et les Technologies). Retrieved from https://halshs.archives-ouvertes.fr/file/index/docid/1020705/filename/people_and_technology.pdf

Trouche, L. (2004). Managing the complexity of human/machine interactions in computerized learning environments: Guiding students' command process through instrumental orchestrations. *International Journal of Computers for mathematical learning, 9*(3), 281-307.

Trouche, L., & Pepin, B. (2014). From instrumental to documentational approach: towards a holistic perspective of teachers' resource systems in higher education. *Research in Mathematics Education, 16*(2), 156-160.