Supplementary Video Lectures and Open Educational Resources in Contemporary University Mathematics

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Oskar Andersson and Stephanie Dawoud
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Abstract

Several universities have begun approaching the Internet as yet another channel in education. Meanwhile, students at KTH Royal Institute of Technology in Stockholm are struggling with mathematics at a university level. As a nation known for its vivid Internet activity, perhaps the new, connected generations' attitude towards traditional learning has swayed in favor for new, web based educational approaches? Personal experiences suggest that that is the case - students at KTH are already complementing traditional studies in mathematics with online lectures from MIT and Khan Academy among others.

This report examined if and how open educational resources could assist in learning mathematics online at a university level. For this purpose, a web page was developed where relevant online material were collected as a complement to traditional education. The usage of this web page was thereafter analyzed in conjunction with questionnaire answers and interviews in order to answer the following question:

> *"What effect do web based video lectures, as a complement to mathematics education at KTH, have on the students' results and attitudes?"*

The report concludes that both more quantitative and qualitative data is needed in order to decide if web based lectures affect the result of the students in the study group. Despite this outcome, qualitative data indicate a positive effect on the student's mindset in mathematics, with increased confidence and comfort, and ultimately; a more positive attitude towards studies in mathematics.

Kompletterande videoföreläsningar och öppna lärresurser i samtida högskolematematik

- En studie om effekterna av ett webbaserat utbildningshjälpmedel för en kurs i Flervariabelanalys på KTH.

Sammanfattning

Flera universitet har på senare år börjat betrakta Internet som en extra kanal i undervisningen. Under tiden kämpar KTH studenter med matematiken på universitetsnivå. Som en nation känd för sin aktiva internetanvändning, kanske den nya, tillgängliga generationens attityd mot traditionell undervisning har skiftat i fördel för nya, webbaserade utbildningsverktyg? Personliga erfarenheter visar att så är fallet - studenter på KTH komplimenterar redan traditionell undervisning i matematik med online-föreläsningar från bland annat MIT och Khan Academy.

Det här arbetet undersökte möjligheten för webbresurser att stödja matematikstudier på högskolenivå. För att undersöka detta utvecklades en hemsida där relevant onlinematerial samlades som komplement till traditionell undervisning. Användandet av denna hemsida analyserades tillsammans med enkätsvar och intervjuer för att besvara frågan:

> *"Vilken effekt har webbaserade videoföreläsningar som komplement till matematikundervisningen på KTH för studenters resultat och attityd?"*

I rapporten dras slutsatsen att både mer kvantitativ och kvalitativ data krävs för att avgöra om webbaserade föreläsningar påverkar studenternas resultat i målgruppen. Trots denna slutsats, påvisar kvalitativ data en positiv effekt på studenters tankesätt, med ökad självsäkerhet och trygghet, och slutligen: en mer positiv attityd gentemot matematikstudier.

1 Introduction

This chapter is an introduction to the problem that will be discussed.

1.1 Background

1.1.1 Introduction

"Open Educational Resources", or OER is a term that has gradually grown over recent years, as several universities have begun approaching the Internet as yet another channel in education (Brown & Adler, 2008). The term builds on a philosophy that education should be made free to access online. For example, Massachusetts Institute of Technology (MIT) has made video lectures of higher mathematics available for the public, and are now launching an e-learning platform called MITx (Allen, 2011). This year, the Department of Computer and Systems Sciences (DSV) at Stockholm University, has initiated an open course project to let anyone access their material online (Schulman, 2012). In April 2012, the non-profit organization TED-Ed released a new way to teach with videos at a new online portal (McManus, 2012).

Meanwhile, students at KTH Royal Institute of Technology in Stockholm are struggling with mathematics at a university level (Royal Institute of Technology, 2012). As a nation known for its vivid Internet activity (Statistiska Centralbyrån, 2012), perhaps the new, connected generations' attitude towards traditional learning has swayed in favor for new, web based educational approaches? Personal experiences suggest that that is the case - students at KTH are already complementing traditional studies in mathematics with online lectures from MIT and Khan Academy among others.

A natural question to ask is therefore; can online lectures and OER help traditional students performances and enhance their learning experience?

1.1.2 Early studies

Online lectures are a relatively new phenomena, but recorded lectures (audio or video) have been studied for at least 70 years (AECT, 2001). It is said that video lectures have several benefits, including the ability for a student to rewind and pause. For example, a study of a Psychology class in 2008 showed that media player features indeed did help student performance (John N Bassili & Joordens, 2008). The ability for students to pick their own pace with recorded lectures is an important factor that affects student confidence positively (Inglis, Palipana, Trenholm, & Ward, 2011).

In a study from 1962 at the San Francisco State College, it was concluded that taped recorded lectures were an effective feature in classroom education, with no difference in student

performance in comparison to conventional teaching (Popham, 1962). However, still having to physically go to the classroom in 1962 to attend and watch the lecture differs greatly from today where you are able to access lectures online in the convenience of your own home. Is this a problem? Other studies indicate increased procrastination and inferior results among users of web-based learning tools (Le, Joordens, Chrysostomou, & Grinnell, 2010). The experiments carried out in the study showed that mathematics students, who regularly used the web tool and frequently paused to take notes, were the ones who performed the most poorly. The authors mean that some mathematics students find the subject so challenging that they use web based lectures and material as a surface strategy. The students believe that they are being productive, but are actually procrastinating as they're only memorizing and therefore postponing achieving deep knowledge.

All in all, studies mention that the results need to be further discussed, as student performance and learning experiences are individual and influenced by many different factors, such as computer efficacy and motivation. Considering the conflicting studies above, coupled with the experience that KTH students already have begun utilizing video lectures online, it is of interest to investigate this subject closer at a local level.

1.2 Purpose

The purpose of this report is to examine if and how open educational resources can assist in learning mathematics during a course at KTH. The effect of introducing online, complementary learning materials to KTH students in mathematics studies will be evaluated. In particular, focus will concern video lectures.

The concept is to gather relevant learning materials, such as video lectures from MIT and Khan Academy as well as lecture notes, for a selected course on a self produced web portal – Flervarreportalen. Thereafter the data and statistics from the website will be analyzed. This data will be complemented with questionnaire responses and interviews.

1.3 Delimitations

The report will focus on the mathematics course Multivariable Calculus (Flervariabelanalys, SF1626). While being a complex course it is also required by the majority of engineer students at KTH. As it is not the first mathematics course for the students at KTH, there is the advantage of being able to compare students' individual results in this course with their results in earlier mathematics courses.

This course, therefore, serves as an ideal module to analyze. The course began in January 2012, including second year students from the Media Technology program as well as first year students from the Vehicle Technology program.

The platform developed for the study is the website (www.flervarre.se), that can be accessed with a CAS-login[1]. This limits the target group to only KTH students or KTH teachers and helps to identify the users.

The videos on the platform were chosen in collaboration with the course responsible teacher, and consisted of a mix of short (10 minute) to longer (50+ minutes) lectures, in ambition that several choices would provide interesting user data for the study.

1.4 Problem definition

The main question of this study is; *"What effect do web based video lectures, as a complement to mathematics education at KTH, have on the students' results and attitude?"*

In order to answer this question, it has been broken down into the following segments;

- What grades are the students getting and is there a correlation between using the web-based tool?
- What user patterns and trends occur? E.g. do students log in at a certain time in relation to the course advancement?
- What role does the interface design and functionality design of the web portal play?
- What are the students' personal opinions on using the system - how has it affected their motivation, results and confidence in mathematics?

[1] *Central Authentication Service (CAS) is a login service that allows you to access multiple password-protected web systems after logging in once on a central authentication server; this is often referred to as single sign-on.*

2 Theory

In this section topics and terms relevant to this study are presented and discussed. Among them are; Open Educational Resources (a key term in online learning which is used throughout the study), the influence of online lectures on student performance (which is relevant for us when analyzing our results), and the psychology behind learning mathematics.

2.1 Introduction to Open Educational Resources (OER)

E-learning is a term used to describe all types of electronic learning and teaching. Open Educational Resources (OER) is a type of e-learning used when referring to digital materials that are used for learning, teaching, research or other educational purposes (Wenk, 2010). The material is available online and free of charge for anyone to use and usually promoted by universities or other organizations. This is furthermore the definition that will be used and referred to in this study.

The United Nations Educational Scientific and Cultural Organization (UNESCO) first introduced the expression OER at a conference in 2000. The term was promoted with the perspective of providing worldwide high-quality educational resources free of charge. Both large institutions as well as small organizations initiate OER programs. According to the Organization for Economic Co-operation and Development (OECD), there are over 300 global universities offering open educational resources, yet this number is steadily growing. In 1996 Sir John Daniel wrote that

> *"More than one-third of the world's population is under 20. There are over 30 million people today qualified to enter a university who have no place to go. During the next decade, this 30 million will grow to 100 million. To meet this staggering demand, a major university needs to be created each week."*

In this study, focus will be concentrated on investigating OER as a complement to mathematics studies; however, research has shown that, like Sir John Daniel predicted in 1996, OER is beginning to replace traditional learning to meet society's demand for education. As of recently, students are able to gain an MIT degree if examination requirements are met despite merely having used OER (Ossiannilsson & Creelman, 2012). This fact consequently confirms that OER are qualitative enough to affect students results, on the other hand, other studies have showed that when given a choice, students who've used OER as a substitute for ordinary lectures in mathematics tend to produce poorer results (Le et al., 2010). The paper suggests that this outcome is due to, student who watch online lectures and frequently pause the videos, tend to memorize the content rather than actually learning how to implement the information.

2.2 The influence of online lectures on student performance

At university level studies, students are expected to have enough self-discipline and ambition to do well and reach their personal academic goals. With the rapid advances in technology, it has become customary for universities to offer students several options in how they learn and study (J N Bassili, 2006). In earlier times the main resources available were live lectures and the library. Today, students have access to online lecture notes, online forums, online lectures, and other online materials as a complement to the conventional resources.

Studies have showed that a majority of students are optimistic towards the use of online lectures but that their results are not related to this habit (J N Bassili, 2006). This outcome is supported by Clark (1989), who states that;

> *"Media are mere vehicles that deliver instruction but do not influence the student achievement."*

In agreement, other research has showed that students who mainly used online lectures were the ones who performed most poorly (Le et al., 2010).

In the study by Le, Jordens, Chrysostomou & Grinell (2010), it was initially predicted that the pause and search functions of the web tools would enhance learning. However, it became evident that students who used these features often embraced a surface strategy of learning, resulting in poorer performance than in conventional teaching in a calculus course. While the authors link a surface strategy of learning to *procrastination,* this behavior in itself was, according to the authors, a result of students finding the subject too challenging to give any real effort, thus making this more of a *motivation* issue among certain students. At the same time, a psychology class in 2008 showed contradictory results, where the media player actually did improve student performance and results (John N Bassili & Joordens, 2008). While this may only indicate that psychology, as a subject is more suited for online learning, it still hints that students learn differently.

With the varying studies above in mind, it can be said that student performances using online tools has no definite universal answer, although the majority of articles used in this report indicate negative effects. The mathematics lecturer who was responsible for the multivariable calculus course at KTH emphasized during a meeting (2012-01-16 at KTH) that many factors play a part in the performance of students in university mathematics. Articles used in this report also indicate that other factors rather than technical play a part in student performance, like computer efficacy, motivation, and learning style among others (Chou & Liu, 2005). Therefore, it is of interest to delve deeper and learn more about different learning styles and the psychology behind learning mathematics.

2.3 Learning styles in conjunction with online lectures

It is no revelation that humans and especially students learn at a different pace and benefit from different teaching methods. Research on learning styles has been performed since 1894 (Learning Styles, 2010) and the united agreement affirms that one's way of learning is solely related to the individual. In 1970, the Dunn and Dunn model was developed based on extensive research proving that when people are taught according to their individual learning styles, their academic performance increases.

Studies have shown that in your youth, one's natural sleeping patterns shift and sleep is needed and preferred during the late morning hours (The Sleep Well, 2000). As seen in the Dunn and Dunn model, time of day is an important element in learning, found under the category; physical, one of the five strands in determining how we learn (Learning Styles, 2010). Considering this fact, OER could be seen as a positive complement as students have the freedom to view lectures and other material at their chosen time of the day.

Several studies show that traditional learning is closely related to the unique individual, which, however, also applies to web based material (Graf, Liu, Kinshuk, Chen, & Yang, 2009). A study from 2009 researched the relationship between learning styles and cognitive traits in web-based educational systems. This paper showed that taking individual differences into account when producing online teaching material is equally important for the students to generate good academic results (Graf et al., 2009). The study also emphasized the importance of implementation of web-based tools when used as a complement to traditional lectures - which is a reoccurring reflection in this study.

2.4 Psychology behind learning mathematics

Studies have shown that there is a relationship between the students' talents and the learning environment (Webster & Fisher, 2003). It is said that students' attitudes have a direct correlation to how well they perform. Consequently students who have a positive approach towards mathematics generally do better in specifically mathematics (Webster & Fisher, 2003). In a study from 2010 (Reed, Drijvers, & Kirschner, 2010) with students learning mathematics using a computer tool, students with a generally positive attitude towards mathematics exhibited better results, further confirming the importance of attitude in learning mathematics.

The problem of learning and comprehension can be found in many subjects, but is especially noticeable in mathematics as it the most abstract, yet powerful theoretical system (Skemp, 1987). Skemp believes that the difficulty for mathematics lies in the fact that children and older students are not actually learning mathematics. He continues to write that the students are inflicted with the manipulation of symbols with little or no meaning, as a result of memorizing rules. This is continuously the reason for students' struggles in mathematics, as unconnected rules are more

difficult to remember than integrated structure (Skemp, 1987). A solution for this problem, as suggested by Skemp, is to, at a young age, teach mathematics to children by visualizations to enhance understanding rather than memorizing. A visualization tool has not been investigated in this study, but would arguably be easily implemented in connection with video lectures or using a web-based platform.

2.5 Traditional vs. online lectures

While teachers may worry that student attendance in regular lectures will drop when given access to supplementary recorded lectures, it is reported that students still value the interactivity that face-to-face classes give (Inglis, Palipana, Trenholm, & Ward, 2011). This is consistent with what Professor Martha Cleveland-Innes conveyed during an interview (2012-04-19); interactivity with students is of high importance. However, interactivity is not something exclusive for live classes; it can successfully be implemented in online tools using for example chat and assignments (Cleveland-Innes, interview 2012-04-19). Design had a significant impact on the nature of the interaction and whether students approached learning in a deep and meaningful manner. Structure and leadership were found to be crucial for online learners to take a deep and meaningful approach to learning.

As with all comparisons, traditional opposed to online lectures, both have their advantages and disadvantages. The main advantage regarding online lectures is the flexibility it offers. Online lectures and material can be accessed wherever you are, with few requirements like an Internet connection and a suitable platform. Other flexibilities include the ability to fast forward and rewind lectures and therefore choose what you want to watch. With this flexibility, however, comes the duty of being responsible for your studies. Studies have shown that the students who produced good results and preferred to use online lectures in front of traditional lectures, despite having the choice, tended to be older than students who chose traditional lectures (Dutton & Dutton, 2002). The study suggests that the age difference is due to maturity, but also showed numbers that the students in general who used online material, as a complement, produced better results than those who only attended traditional classes. On the other hand the same study shines light on the positive aspects of traditional lectures such as contact with the instructor and motivation received from class encounters.

3 Methodology

This section covers the methods that were used to carry out the investigation. In order to answer our research questions, several different methods have been used.

User statistics from the website answered questions about user trends & patterns, while the questionnaire supported these statistics as well as caught a few personal opinions about interface design as well as student attitude and confidence. Interviews were conducted in order to get more personal opinions and to go more in depth with a few of the questionnaire answers.

3.1 Literature study

To find relevant texts for the research, the KTH library article database as well as Google Scholar and articles recommended by lecturers and classmates have been used. The search terms used were "open courseware mathematics", "learning mathematics", "interactive learning mathematics", "learning styles", "recorded lectures" thus several interesting articles and scientific reports were found.

Articles were also found in the high-ranking journal, *Computers and Education* as well as *The Journal of Computer Assisted Learning.* Further articles of relevance were thereafter found from the reference list of original articles and citations.

The articles used, and referenced to, discuss Open Educational Resources in general, MIT's "Open Course Ware"-program, a comparison of different e-learning tools, pedagogical learning in mathematics, learning styles and the individuality in students' comprehension and attitude when using digital tools.

3.2 User statistics from the website

Since the investigation focuses on students' use of Open Educational Resources, a way had to be found to study this usage. However, there was a lack of control and access to detailed statistics of the various external organizations that provide OER. Moreover, the goal was to create a streamlined tool that suited the study group's needs, so that students would want to use the tool. With this system, full control and flexibility in what statistics to gather was a priority.

The solution was to develop a new web portal, www.flervarre.se, called "Flervarreportalen". While the site is described in full in section 4, it can be briefly noted that the website featured custom built statistics scripts and a login service that allowed only KTH students to enter, but most importantly, relevant OER (video lectures and lecture notes) for the students in the chosen

study group were gathered and presented. As mentioned in section 1.3, the target group was the course in Multivariable Calculus ("flervarre", slang for "Flervariabelanalys" in Swedish) at KTH, and the OER were gathered with that particular course plan in mind.

By logging the activity on Flervarreportalen, information in the shape of quantitative data was established over the user trends of the website users. The data gathered included:

- Activity on the site - which links, videos and other content users clicked on and when.
- User background data - platforms used and university ID (KTH-id) of the users.

From this data information such as how many unique visitors the website received was derived, as well as establishing peak activity hours, determining which videos that were accessed and which videos or elements of the page were the most popular (clicked).

3.3 Obtaining material

To be sure that the website consisted of appropriate and qualitative material, videos were gathered from MIT and Khan Academy in collaboration with the lecturer responsible for the course. All videos were watched to make sure that the content was relevant to the respective lectures in the course plan. The assortment was thereafter sent to the responsible teacher for further validation and confirmation.

Lecture notes were also scanned and published on the website with the approval of the author, an associate at the department of mathematics at KTH. Supplementary material made available on the website was a Swedish-English mathematics glossary to assist the students with language barriers.

3.4 Questionnaire

An online questionnaire was sent to all 150 students in the study group as well as posted on Flervarreportalen, to complement the numerical data received from the website as well as qualitative data in the form of personal opinions and experiences. This contributed to answer the research question about students' attitude and confidence, as well as support and confirm the website statistics.

The advantage of using a questionnaire is that one is prone to reach a numerous amount of students. Disadvantages, however, are the lack of control one has over the response rate and the truthfulness of the answers. Students had the choice of being anonymous or not. This decision was made so that students who wanted to remain anonymous still were able to take part of the questionnaire. The answers of the students who chose not to be anonymous, however, were easily compared with individual website statistics for additional validation. In an ideal scenario,

all of the respondents would have chosen not to be anonymous, but to retrieve as many answers as possible the choice was made available.

Questions that were used consisted of both closed ended questions, such as *"Have you skipped scheduled lectures because of Flervarreportalen?"* as well as open-ended questions, such as *"How have you used Flervarreportalen? If not at all, why?"* Closed ended questions used included multiple choice and yes/no questions, as they are straightforward with answers limited to a certain number of alternatives. These helped gather quantitative data, which were needed to answer the research question about user trends and patterns. On the contrary, open ended questions such as unstructured questions; enable the respondent to provide their personal answer without being limited to a certain set of answers (Holbrook, Green, & Krosnick, 2003). Open-ended questions therefore allowed receiving more personal opinions and answers suited to answer the research question about motivation, confidence as well as thoughts about interface design.

3.5 Interviews

Interviews were used to obtain further qualitative data. In order to gain both a top down perspective as well as student/user perspective on the problem area, the choice was made to conduct two different kinds of interviews.

The top down perspective interviews focused on OER and web-based learning in general and was conducted on Professor Martha Cleveland-Innes from Athabasca University in Canada. Professor Cleveland-Innes, having spent 29 years within the field of distance education, came with experienced input regarding OER in broad as well as feedback on the idea of Flervarreportalen. Because of this, the choice was made to include her in both the theory section above, as well as when discussing our results below.

The second part focused more on the perspective of the students who had used Flervarreportalen and OER in education, and included four KTH students who participated in the Multivariable Calculus course.

The interview method used was semi-structured for all interviews. As a comparison to structured interviews, where the interview follows a strict limited set of questions, semi-structured interviews are more flexible and open up for spontaneous questions along the way (Lindlof & Taylor, 2010). All interviews were recorded to increase remembrance and making sure that quoting was correct.

An outline of themes and topics to be brought up was however planned in advance, but the interviewer was able to ask follow up questions if needed. In this particular case, carrying out

semi-structured interviews was favored as the aspiration was to acquire as many personal opinions as possible regarding functionality as well as interface design. The interviews were, however, mostly conducted to gain a better understanding of what effect web-based resources had on the attitude and motivation towards the subject as well as comprehension and understanding. Following a strict interview-structure would therefore limit the range of questions, which in return would reduce the usefulness of the interviewee's response.

4 The website, Flervarreportalen

This section introduces the website (www.flervarre.se) titled Flervarreportalen. The technical aspects involved in the site are covered. The database structure is presented, as well as reasoning behind certain design choices.

Because of limited time and resources, the site is not intended as an example of good human-computer interaction, as it was only designed to help gather user statistics of OER usage in mathematics. The purpose of this report is therefore not to evaluate different design concepts and human-computer interaction theories. However, it is worth noting that the design choices may have affected the results of the study, which is why this section is of interest in order to later highlight potential experiences in this regard.

4.1 Introduction to Flervarreportalen

The decision to go for a non-traditional visual touch was an intent to spark interest in students visiting the site, while keeping simple elements such as the top menu bar for easy navigation (see Figure 2).

Figure 1: *The start page.*

The large, centered log-in link (“Logga in via KTH”) as seen in Figure: 1, utilized KTH’s website’s existing login system, or Central Authentication Service (CAS), meaning the users were limited to only KTH students and teachers, as well as being able to store the KTH-id of visitors. This means that users were easily identified when logged in.

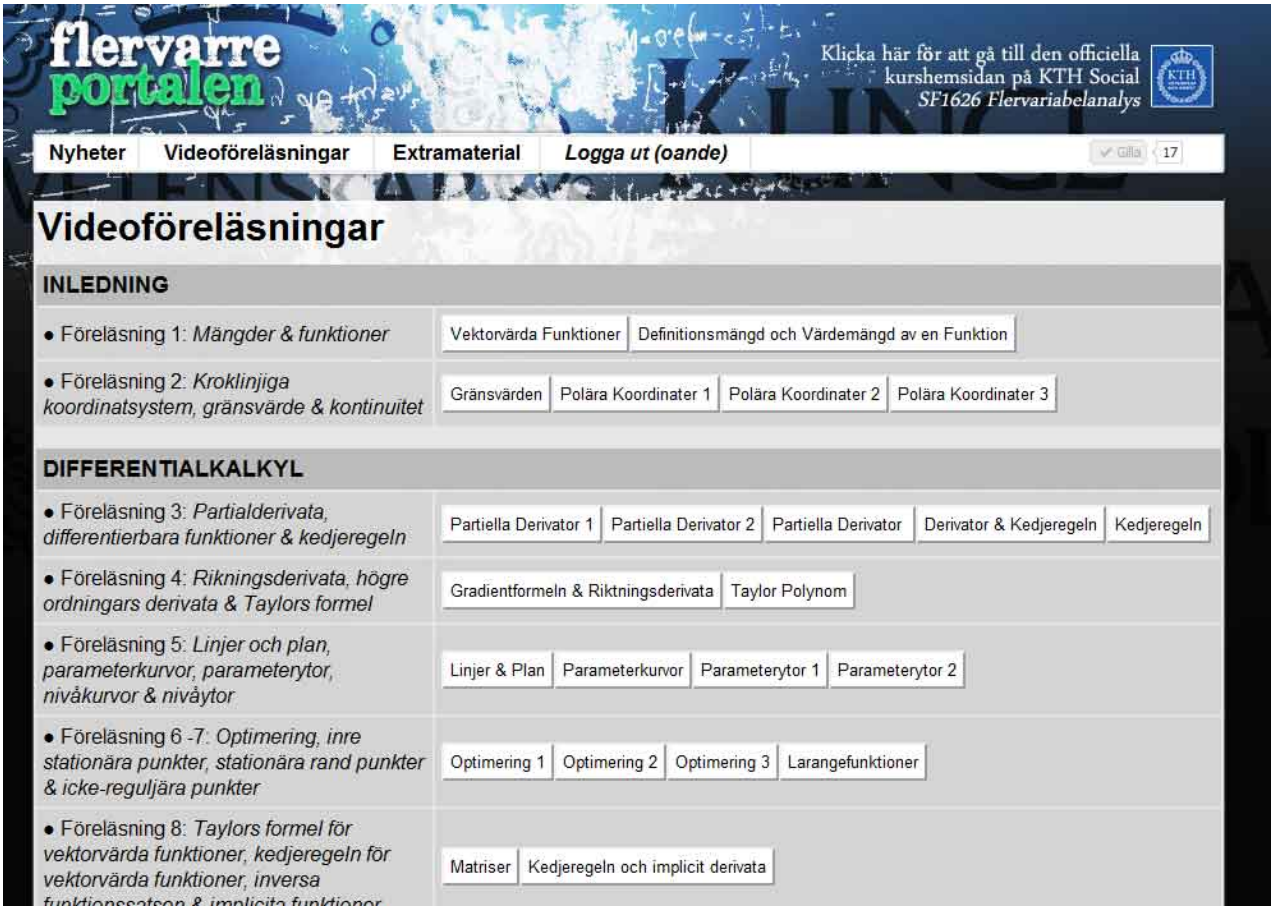

Figure 2: *Video lectures.*

When logged in, a news page initially greeted users, and after clicking on “Video lectures” (“Videoföreläsningar”), see Figure 2, users accessed what was intended to be the main part of the site. All relevant video lectures were gathered here, and organized according to a specific layout that followed the particular course plan of the study group and course; Multivariable Calculus (course code SF1626) at KTH.

The videos were each coupled to a lecture, which in turn were organized under different sections according to the course plan, starting off with Introduction (“Inledning”), Differential Calculus (“Differentialkalkyl) and Integral Calculus (“Integralkalkyl”).

In deciding the above layout logic, as well as what OER to gather and use, help was provided by the lecturer responsible for the course. In agreement with the responsible teacher, longer video

lectures from MIT Open Courseware (50+ minutes), as well as shorter (~10 minutes), with more detailed clips from Khan Academy were used.

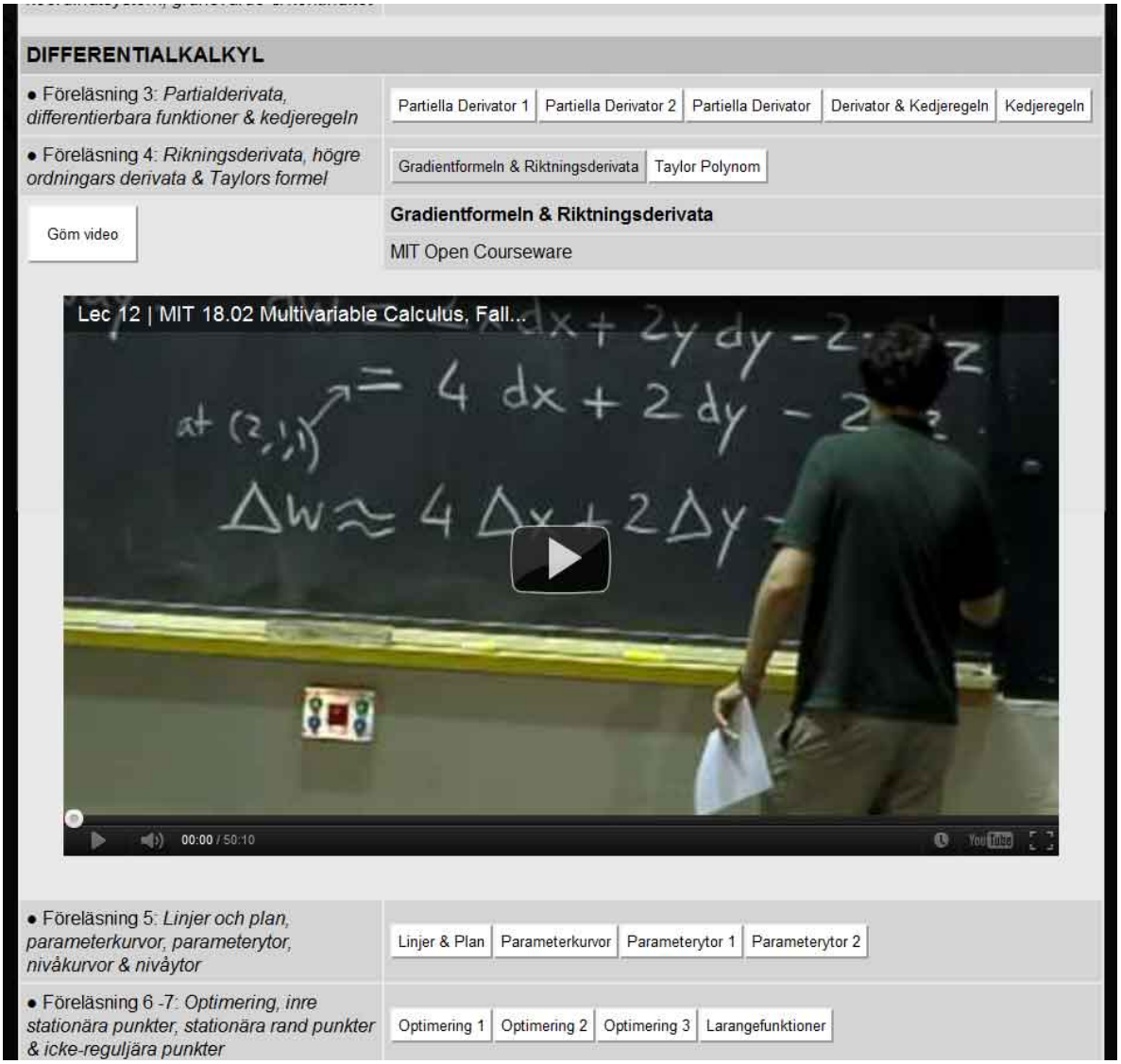

Figure 3: *A user has clicked on an MIT video lecture.*

The site also featured a page with extra materials (“Extramaterial”), with scanned lecture notes made by an associate at the department of mathematics at KTH.

Lastly, in order to generate extra traffic, a Facebook-“Like”-button was added where students could promote the site to their classmates through Facebook. There was also a link to the official course website as seen in the upper right corner in Figure 2, which in turn had links back to Flervarreportalen.

4.2 Technical details and database

The site was built using a combination of different programming languages and techniques listed below:

- PHP - allowed for a simple connection to the MySQL-database as well as generating our XML structure. User data was gathered and sent to the database here.
- AJAX - helped to keep the experience "smooth" for the user by not having to reload the entire page for each video link clicked (see Figure 3), promoting a behavior of exploring and testing within the web-page. Also helped with specific user data sent to PHP.
- XHTML - the entire database structure was built up in an XML-fashion to allow for presentation and usage within HTML with XSLT. This is what the user sees.

The main point of the site was to gather user statistics of usage, and therefore, every link clicked generated a log entry to the database. This log entry contained information about what the user clicked (e.g. a video link), at what time, and with what platform (e.g. iPad).

One limitation of this system was that it did not record if the user actually *watched* anything. It only showed that the user *clicked* on a specific video link that was embedded on the site. Because of this, the main tool to measure site activity consisted of amount of clicks per user.

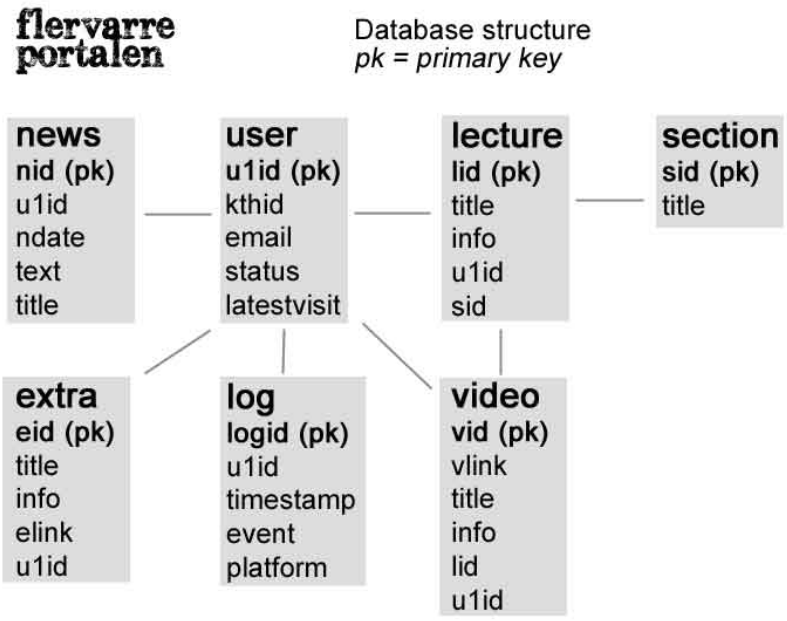

Figure 4: *The database structure of Flervarreportalen.*

The size of the database was seven tables. This reflected the size of the site itself, as it was a relatively small site with only four web pages (including the start page). One "user"-element was generated for each unique KTH user, and every time a user clicked something, a "log"-element

was created that described that event. The material on the website were stored as “extra”- and “video” elements (see Figure 4).

5 Result

This area will cover the data and results collected through website statistics, questionnaire answers and interview responses.

5.1 Website statistics

Since the first day of the course, January 16th, until (and including) the day of the exam, march 13th, Flervarreportalen received a total of 388 unique visitors. The course round that this investigation followed consisted of approximately 150 Media Technology (year two) students and Vehicle Engineering (year one) students, meaning that the 238 remaining visitors were students from other programs as well as curious teachers.

After looking through the database, it was estimated that the effect of temporary visitors (such as teachers) on the statistics were negligible, while students from other programs still were interesting to the overall statistics as they also participated in the same course in multivariable calculus as the study group. Therefore they are also part of the general, total visitor count. However, when looking at more detailed statistics later on, only students from the study group were included.

5.1.1 Unique users per day

When visualizing the number of unique visitors per day between the period of January 16th and march 13th, it is visible that there is a fluctuating pattern. As seen in figure 5 below, there was one distinctive peak eight days after having launched the website, perhaps a result of the novelty effect (Teukolsky, 1976), and four subsequent peaks of smaller dimension. In correlation with the course plan, it is interesting to note that the third peak occurred on the 29th of January, one day prior to the first quiz.

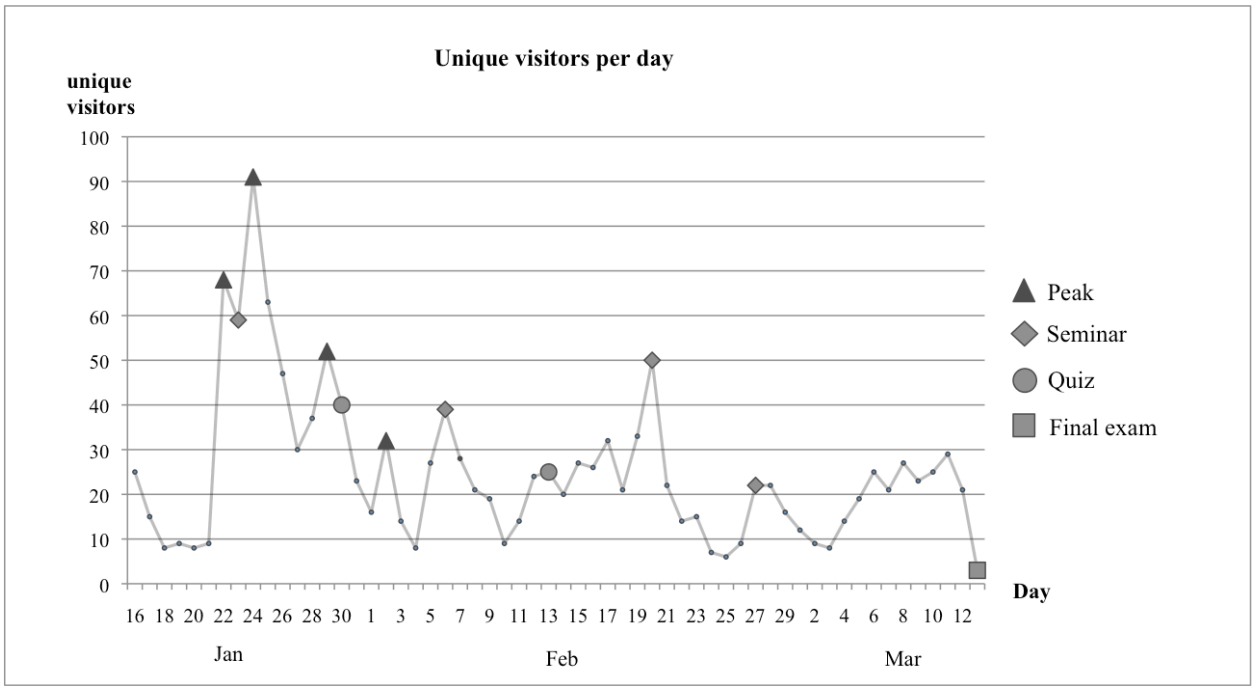

Figure 5: *Graph visualizing number of unique visitors per day during the period Jan 16 to Mar 13.*

There was, however, no noticeable change in activity in close connection to the second quiz, as the closest peak occurred six days in advance. Nevertheless there was an interesting relationship between peaks and time of seminars[2]. The first noticeable peak intervened on the 22nd of January, which was one day prior to the first seminar. The second seminar took place on the 6th of February, which was the same day when a noticeable increase in activity occurred compared to the two previous days. The same behavior is visible on the 20th of February, which was the day of the third seminar. An obvious increase in activity occurred on the same day of the seminar compared to the previous two days. Finally, the last seminar was held on February 27th and 28th, and as seen in the graph, both these days showed the same amount of activity, which was in fact a clear increase compared to the three previous days.

This information could suggest that the students studied one day in advance for the first seminar, but crammed in the information on the same day of the remaining seminars. However, all seminars were held between eight and ten o'clock in the morning, suggesting that the students using the website either studied late after midnight or that there was no direct correlation between website activity and the day of seminars. As gathered from website statistics, however, there is no sign of noticeable increase in activity after midnight compared to the remaining time of the day. The day of the second seminar 11/39 students accessed the website before or during the seminar. On February 20th, when the third seminar was held, only 8/50 students used

[2] Seminars are occasions where students are expected to account for a certain number of pre-assigned exercises to gain bonus points for the final exam.

Flervarreportalen before of during the time of the seminar. As for the last seminars on the 27th and 28th of February the outcome was similar as 4/22 respective 2/22 students entered the web site before or during the seminar. In fact, most activity on Flervarreportalen was evenly distributed and occurred between the time period of ten o'clock in the morning and midnight.

5.1.2 Clicks per video

Figure 6 shows a graph visualizing the number of clicks per video. At a glance it is clear that the first half of the videos have received almost twice as many clicks as the latter half. This fact is supported by the questionnaires where it became apparent that a majority of the students who used the webpage were frequent visitors in the beginning of the course. This number, however, almost halved towards the second part of the course, possibly as students found other sources for video lectures as reported in the questionnaire (below), or/and perhaps also a part of the novelty effect.

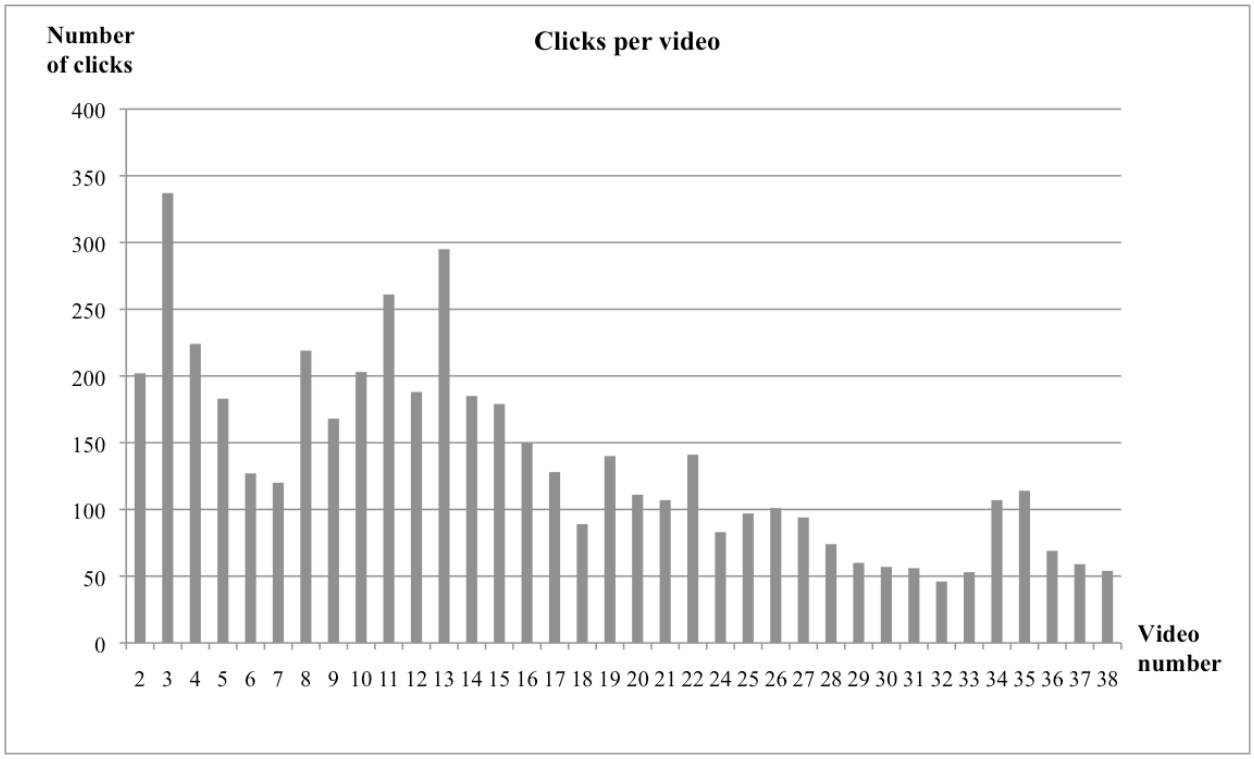

Figure 6: *Graph visualizing the number of clicks per video*

Looking more specifically at figure 6, four peaks are visible, implying many clicks on videos, 2, 8, 11 and 13. All of these videos are material from Khan Academy, supporting the comments in the questionnaire concerning video length. A few students noted that they preferred watching Khan Academy material, as they were shorter, yet covered a specific topic.

5.1.3 User background

Time of day

By counting the amount of unique users that had been active during a given timeframe, the most popular timeframes for using Flervarreportalen were determined, as well as general platforms.

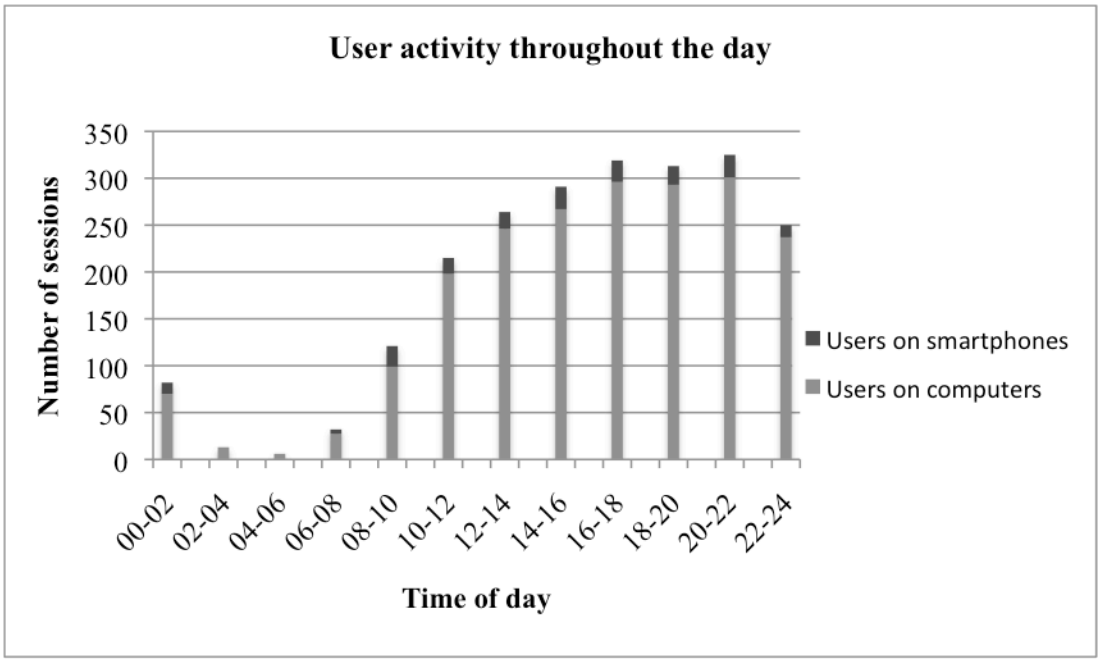

Figure 7: *Graph visualizing the total number of user sessions[3] per hours during the period 16th of January to the 13th of March.*

In the above graph it is clear that user activity reached a peak between 16:00 - 22:00 pm, with a slight dip around 18:00 - 20:00, perhaps due to it being a usual time for dinner. However, looking at overall user activity in Figure 5 it is clear that the majority of this activity came from the early part of the course.

Platforms

By logging the web user agent (HTTP_USER_AGENT), the most common user platforms were retrieved.

While Figure 7 shows desktop or laptop computers in dominance, the table below reveals more in depth the most common operating systems used during user sessions. This data was produced by counting how many times each platform was used each day per user, meaning that active users of the site influenced this data more than inactive users.

[3] A session refers to the time of activity between logging in and out by a unique user.

Table 1: *Most common platforms used amongst users of Flervarreportalen*

Most common platforms used amongst users of Flervarreportalen
Windows: 53.38%
Macintosh: 33.08%
iPhone: 4.12%
iPad: 2.02%
Android: 1.7%
Ubuntu/Linux: 1.75%
Other / inconclusive data: 3.95%

Given the above table, it can be noted that handheld (Smartphone & iPad) devices consisted of less than 10% of all the usage, while Windows PC (laptop or stationary) dominated with over half of all users, followed by Macintosh (laptop or stationary) with one third of all users.

5.2 Questionnaire responses

The questionnaire was sent to approximately 150 students, whereas 22 answers were received. The few responses gained, showed that the majority of the students who participated in the questionnaire, believe that the website was a good idea and served as a useful complement. The questions that were asked mainly focused on how the individual had used Flervarreportalen and their personal opinions of the functionality of the website as well as the idea in general.

Worth noting is that among these 22 answers, 6 came from students at programs outside Media Technology or Vehicle Engineering, but their answers were still valued as interesting for this investigation since they participated in the given course and contributed to the site statistics.

5.2.1 Statistics

How Flervarreportalen was used

Many students have used the website as a supplement when they, for various reasons, have not been able to attend class. 18 out of 22 of the respondents used the website once a week or less and the remaining four used the website 1-3 times a week. No one used Flervarreportalen more than 3 times a week.

Using Flervarreportalen and KTH lecture attendance

The data also showed that 12 of the respondents have attended 75 % or more of the lectures, three of the respondents attended 50 % - 75 % or more of the lectures, and the remaining seven respondents attended less than 50 % of given lectures. The questionnaire also showed that four out of 22 of the students who responded have deliberately skipped scheduled lectures because of the introduction of Flervarreportalen, while the remaining 18 haven't. This relatively low percentage of students who have skipped class could, however, be due to the lecturer. All

students who participated in the interviews were unanimous that their high class attendance was due to them being fond of the lecturer and his pedagogical teaching in comparison to other mathematics courses and lecturers.

5.2.2 Comments

Improving the concept of Flervarreportalen

A few individuals noted that when watching video lectures one has the advantage of pausing and rewinding to repeat what has been said. Almost all students mentioned that they had used the website as a complement to ordinary lectures, however a handful of students had only used video lectures and therefore replaced ordinary classes. These students said that they were introduced to MIT, Khan Academy and other OER through Flervarreportalen but that they eventually accessed these sources directly as well as searching YouTube.

This behavior supported the opinion that many users saw improvement needs for Flervarreportalen in the form of additional video lectures and from a wider range of sources. In these comments, it became apparent that only two thirds of the course had been covered with the videos, a mistake that is discussed in section 6.1.1.

Decreased interest

Almost half of the respondents used Flervarreportalen frequently in the beginning of the course, however, this interest dropped. The statistics as seen from the web page in figure 6 above confirms this result.

As was brought up in the student interviews as well as questionnaire responses, reasons for this behavior may be that the 50-minutes MIT lectures were considered too long and some of the ten-minute Khan Academy videos too basic, but also that simply not all material was provided, as noted above. Another factor that may have affected this is the novelty effect, with students getting bored of the concept once the “flair of new” had worn off. Questionnaire responses, however, show that students searched for relevant videos and OER on their own once they had lost interest in Flervarreportalen.

The majority of the students in the questionnaire that had been using the website, however, used it seldom but enjoyed the variety of videos and found it effective for revision purposes or in preparation for smaller tests and seminars along the way as well as for the final exam.

5.3 Interviews

5.3.1 Professor Martha Cleveland-Innes

A Skype interview was carried out with Professor Martha Cleveland-Innes, an exchange professor at KTH, who normally teaches at Athabasca University, a university online. The questions asked focused on OER in general and her personal experiences when it comes to online teaching.

Professor Cleveland-Innes begins to explain that there are two types of distance education. The type that was initiated first was offered to students who were not physically able to attend school due to distance or other reasons. At this time traditional teaching was still the preferred choice. However, traditional schools began to see a development potential to enhance their education and marketing scheme by complementing traditional teaching by offering distance education. This difference in objective led to the distinction that institutions, which only offer distance education, nowadays speak almost nothing about the distance itself, but rather focus on how to enhance the online material and interactivity.

When distance education first was launched, a 40 % completion rate amongst students was considered a successful rate as students were self-directed and interaction was minimal. When Professor Cleveland-Innes was asked about the completion rate today, she said it could, in some courses, reach 100 %. This increase, she believes, has some to do with the improvement of the institution and material. However in general, as discussed throughout this study, the main part lies in the students' attitude and motivation. Professor Cleveland-Innes goes on to say that determining what makes a student finish a course is very difficult, and factors such as institution, instructional model, motivation, confidence, self-discipline, and social circumstances all play a function.

> *"Why should anybody own education and knowledge that is good for the world?"*
> *- Professor Martha Cleveland-Innes*

Professor Cleveland-Innes is in favor of web-based tools for teaching purposes, but could not emphasize enough the importance of implementation. With implementation, Professor Cleveland-Innes means that for the web tools to serve their purpose they need to be introduced in a way, which informs students on how the tool should be used, and offer interaction with teachers and or other students. In the case of Professor Cleveland-Innes, online lectures are held live and therefore questions and interaction is more customary than for pre-recorded lectures. This, however, does not necessarily need to be the case if pre-recorded lectures offer a chat function or similar interactivity between teachers and students.

5.3.2. Student interviews

In order to be able to differentiate between answers and still preserve anonymity, the choice was made to call the interviewees A, B, C and D.

Four student interviews were carried out at two different times, first with one student (A), and the other session with three students (B, C, D) at the same time, where students took turns in answering the same questions. All interviewees came from the Media Technology program at KTH. Gender-wise, they consisted of three men (A, B, C) and one woman (D). The questions asked were similar to the ones asked on the questionnaire, but more in depth and detailed discussions were held.

Using Flervarreportalen and KTH lecture attendance

All the interviewees had used Flervarreportalen, however, students B, C and D attended almost all KTH lectures. The reason among these three for missing a lecture was mostly *"bad luck";* being too tired for early lectures (starting 08:00 am) or feeling that the lecture was irrelevant because they were ahead in studies. Students B, C and D all agreed, however, that they felt they had a great lecturer and would probably have used the web tool more if they had had a bad lecturer.

Student A attended almost no live lectures, explaining this as a result of preference for online lectures due to living far away from KTH, coupled with more freedom in planning studies with OER. The same person had started using Flervarreportalen, but later found more videos by himself.

How Flervarreportalen was used

The way the interviewees used the web tool differed slightly. B, C and D had watched video lectures as a complement after conventional lectures, whereas A had only used video lectures and the lecture notes.

All students in the interview watched video lectures "sometimes" to rehearse something that was difficult. Specifically, C used it in study groups when rehearsing prior to tests and final exam, and B when rehearsing prior to seminars. Student A used video lectures and the lecture notes extensively for every part of the course.

Improving the concept of Flervarreportalen

As mentioned earlier by Professor Cleveland-Innes and several previous studies, implementation was a topic that was frequently brought up. All four students saw the need for a web tool such as Flervarreportalen to be integrated in their course. They were all in agreement that an implementation by the teacher and in connection with the course website would be an ideal solution.

When discussing how Flervarreportalen could improve to reach a larger, more frequent audience, the answers and suggestions were many. One of the main requirements was more material in the form of online lectures, and specifically lectures that clearly have been approved by the lecturer so that the students are guaranteed that the content is of relevance. Another criteria was the possibility to interact with teachers and other students. The students saw a need to be able to comment different videos (being able to rate videos was also mentioned) and ask questions to benefit from the material. This thought is a confirmation of the discussions with Professor Cleveland-Innes as well as previous research on online education as a complement to traditional teaching. However, when looking at a study regarding Lecture-based interactive screen casts carried out on the same students, the result showed that majority of the students would rarely or not at all use such an interaction tool to share information with one another. (Lilja & Juntti, 2012)

Grades

Two of the interviewees (A and B) felt that Flervarreportalen and OER have positively affected their grades. The remaining two (C and D) haven't used the website enough to make a judgment, however, they both state that if they had used the website more frequently, they believe it would have had a positive effect on their results.

OER and procrastination

When asked about OER and procrastination, student A mentioned how tired he was after a regular lecture, and often felt like he *"convinced himself"* that he didn't have any energy left to actually do exercises. Often he was physically tired because of long travel times.

> *"A short 10 minute video lecture breaks the pattern of laziness and invites to actually doing exercises faster."* - translated quote from A.

On the flipside, student D mentioned that if video lectures *"could replace"* regular lectures, she would not have gone to regular lectures. This, she felt, would have resulted in more procrastination and worse results due to having to plan her studies alone with no help from the curriculum.

5.3 Multivariable Calculus grade statistics

Math grades were retrieved from KTH with help of our supervisor. In order to have a manageable amount of grades to compare with the website statistics, the choice was made to look closer at the grades from the questionnaire respondents, where we could also analyze the results better with the responses from the questionnaire. After filtering out students that were not part of the Media Technology or Vehicle Engineering programs, this amounted to 16 students in total.

Completion rates
Figure 8, below, clearly shows a large difference in completion rate amongst the two programs. The Vehicle Engineering program reaching a completion rate of 69 %, while the Media Technology program has a completion rate of 39 %. Worth taking into account is that the Media Technology program has had a one year gap since the last mathematics course was held compared to the Vehicle Program which were given their previous mathematics course only one term before. However, the difference between these two programs has existed for years and is not unique for this investigation.

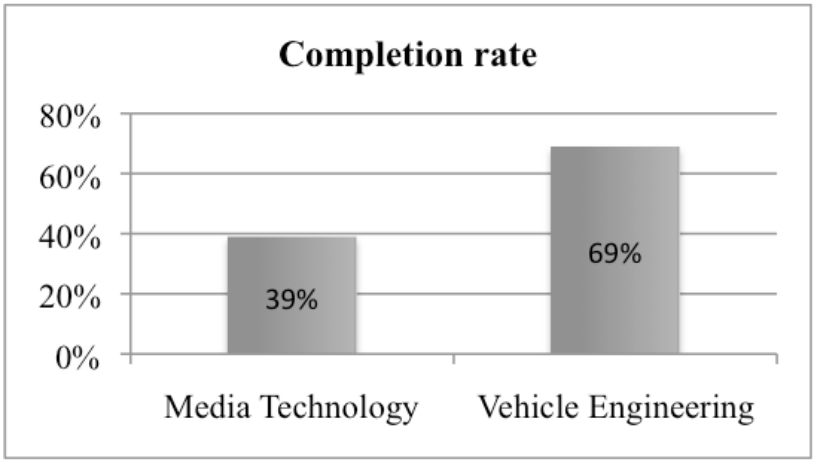

Figure 8: *Staple diagram visualizing the completion rate in the investigated course in Multivariable Calculus the academic year of 2011/2012.*

Important to note is that this completion rate includes earlier course rounds during the academic year as well as the one covered in this investigation. This means that these results serve more as a comparison and interesting fact, as results were needed to be viewed in more detail - see below.

Questionnaire respondents' results and Flervarreportalen-usage
With focus on 16 of the questionnaire respondents, we looked at their grades development and how much they had used the web tool. Questionnaire responses were helpful in analyzing how and if they felt Flervarreportalen had helped in achieving this grade, while website statistics assisted in this data.

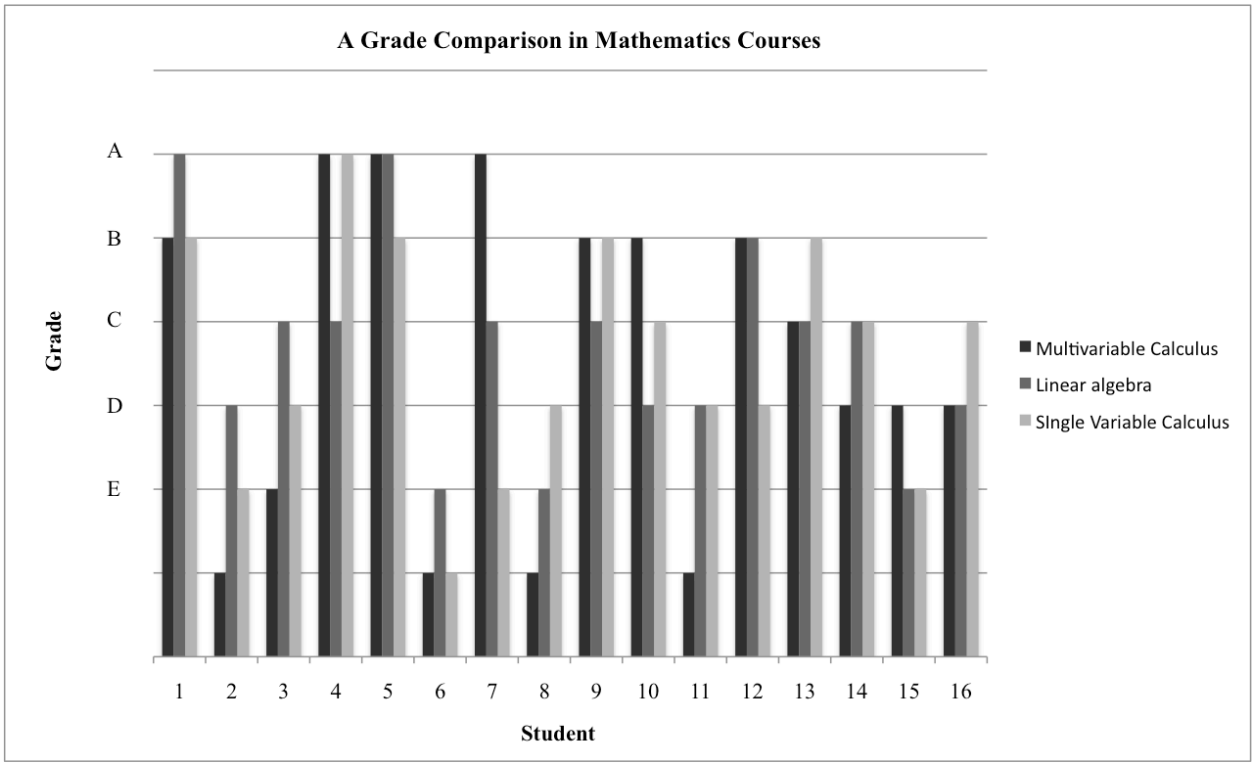

Figure 9: *Graph showing the grade development in three mathematics courses*

Figure 9 shows the students' individual grade development between three recent and similar math courses; single variable calculus, linear algebra and multivariable calculus. This graph shows that only three students actually improved their grade in the multivariable course in comparison with the two previous mathematics courses. Another four performed at the same level as the earlier courses and the remaining nine students produced a poorer result.

It is interesting to note that out of the two students who improved their grade in the multivariable course, one of them was the most frequent user of Flervarreportalen, both in number of logins as well as number of video clicks. On the other hand, the second most frequent user of the website was one of the students who produced a poorer grade in the multivariable course. However, looking at this specific student's questionnaire answers, he or she states that the website was, in particular, used in preparation for the final exam. This could suggest that video lectures and other studies were crammed and therefore led to an inferior result.

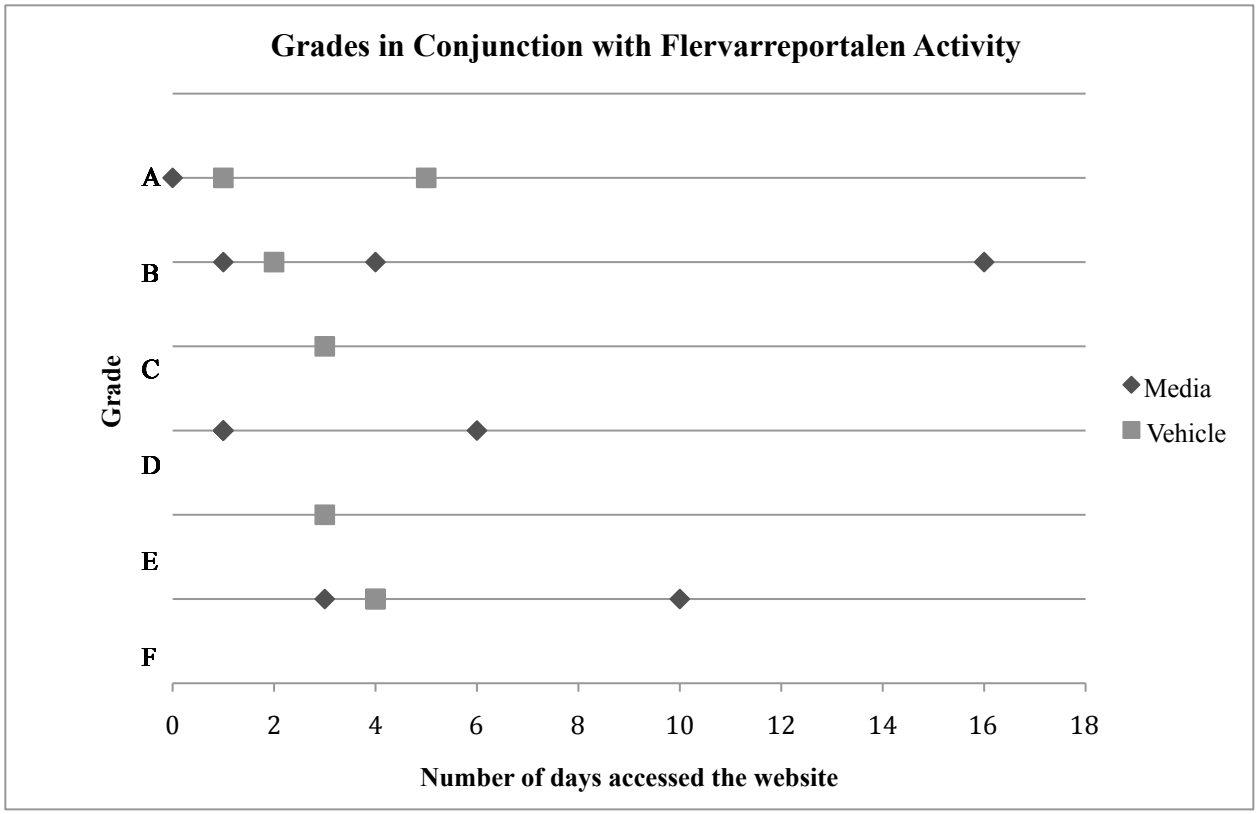

Figure 10: *Graph visualizing the grades of the questionnaire respondents in conjunction with Flervarreportalen activity.*

The above graph reveals that users that had logged on to Flervarreportalen performed in the entire range of grades; F (fail) to A (highest grade), meaning it is difficult to draw any conclusion of this data. The two most vivid users with 10 and 16 sessions had also completely different grades. Interesting to note is that Media Technology students seemed slightly more susceptible to try out the new web tool than Vehicle Engineer students, while grades remained slightly in favor for Vehicle Engineering (5 passed, 1 failed) compared to Media Technology (6 passed, 2 failed).

Looking at these stats in conjunction with questionnaire responses, it can be noted that three students that had used the site extensively said they missed having more videos, and therefore stopped using it in search of other sites that could satisfy their OER needs. Other students only used the site for a few times where they said they were “introduced” to online videos, and abandoned Flervarreportalen in favor of searching by themselves on YouTube or MIT / Khan Academy sites. Five students said they already had good material, and therefore did not use Flervarreportalen.

Only three students attended between zero to 50 % of all lectures, and all of them increased their grade compared to previous math courses. All of the 13 other students in the questionnaire attended more than half of all lectures, the majority over 75 %. The critical number seemed to be around 50%-75% lecture attendance, as 2/3 failed students were in this area.

6 Analysis

In this section, methods and results are evaluated and analyzed with focus on our initial research questions.

6.1 Methodology Evaluation

6.1.1 Obtaining material

A recurring comment from the questionnaire and interviews amongst students was the absence of video material for the last third of the course. As video lectures only were posted for the first two thirds of the course, the results could be misleading, as the beginning of the course is not as advanced as the latter part. However, it is important to acquire the basic knowledge to be able to comprehend the build up material. Unfortunately the absence of videos for the last part of the course was a sincere mistake due to misunderstanding as it was alleged that the whole course was covered with relevant video material. Lecture notes and outline from the previous course round were used to map the video lectures used on Flervarreportalen, as it turned out some material was missing and therefore the last third of the course was mistakenly condone. Although the first two thirds of the video material were indeed checked and confirmed by the lecturer responsible for the course, users may have begun doubting the legitimacy of the material posted, resulting in a decreased number of frequent users.

6.1.2 Questionnaire & Interviews

Unfortunately the questionnaire only received a 15 % response rate, despite numerous reminders in the form of e-mails and in-class announcements. The e-mails and reminders were sent by the teacher responsible for the course in expectation of retrieving a higher response rate, this was however not the case. A better alternative could have been to hand out in-class paper questionnaires, as online questionnaires are easy to overlook and forget, although this could, however, also been a problems had students not been in class. The answers obtained could furthermore have been slightly positively slanted, as some of the respondents are classmates and acquaintances with the authors of this paper. It is also questionable how sincere questionnaire responses were, as students may not have felt comfortable providing sensitive information about themselves, therefore distorting their answers.

Regarding the interviews, it was moreover, unfortunate that only four students participated. Despite several voluntary sign ups for the interview process, the actual attendance was remarkably low. The four interviewees consisted of three males and one female, in an ideal situation the sexes would have been equally distributed, for impartial results. Due to time

shortage the first interview was held individually while the second interview consisted of the remaining three participants. This distribution was not the ultimate model as participants in the second interview could have influenced each other's answers, as some individuals are more loquacious than others. However, this interview could be seen as a focus group which contribute with advantages such as a less uptight environment where people are able to build on other people's responses and think of ideas they might not have thought of in an interview situation.

Lastly, questions concerning outlying factors such as motivation and confidence in mathematics were not included in the questionnaire. This resulted in an inferior capability to draw any conclusion about student results, although answers from the interviews (where these questions were asked) was able to act as guidelines.

6.1.3 Website

Flervarreportalen, the website used to analyze user patterns and behavior, contains several aspects that have affected outcome and results. Despite not having received any criticism regarding the website design, it is possible that design choices have negatively affected the results. Some students may suffer from Internet anxiety, or are insecure Internet users, which leads to them being less likely to use a website such as Flervarreportalen (J N Bassili, 2006). This is, however, unlikely for KTH students and none of the questionnaire responses give any support for this phenomenon.

The statistics gathered from the website could also give a slanted representation of the actual usage. For example the numbers are unable to show how long into a specific video a certain user has watched. Therefore it is difficult to judge whether or not the videos, which showed to be the most clicked, actually were watched or only clicked and then closed down. An evaluation of how long into a video a certain user watched could, however, be obtained by following the specific users timestamp. If the user clicked on a different link only a few seconds later, it is plausible to draw the conclusion that they did not watch the video. On the other hand if this user does not show activity until after 10-15 minutes of having clicked a video, it is probable that they watched the video for the given amount of time. However, since this method was not used due to time constraints in the project, the definition of activity used in this report was instead measured by number of clicks.

The website statistics alone do not answer the question in how the website has affected the students results and attitude towards mathematics. Therefore it was important to complement data with the questionnaire and interviews to gain qualitative data.

6.1.4 Novelty effect

The results received from the website statistics as well as questionnaire responses, both confirm a decreased use of Flervarreportalen midway through the course round. This behavior could be a

consequence of the novelty effect. However, this outcome was thought of beforehand and therefore carrying out the investigation throughout the entire course round of two months, rather than over a chosen part of the course, was an intentional selection. Introducing Flervarreportalen during the first lecture and logging activity until the day of the exam was done in aspiration to minimize the novelty effect.

6.1.5 Grades

As seen in figure 9 regarding the grade comparison between the mathematics courses, it is important to note the data could be slanted due to the four students who failed the multivariable course. It is unknown how many times these students have taken the exam in the two previous mathematics courses. Therefore, to draw the conclusion that their performance has degenerated, is unfounded since they could, for example, have written the single variable calculus and linear algebra exam five times each, but only gotten one go at the multivariable calculus exam. This scenario may be relevant for the remaining twelve students; however, it is highly uncommon for students at KTH to raise their mathematics grades unless they've failed.

6.2 Result discussion

Repeating section 1, the central question asked: *"What effect do web based video lectures, as a complement to mathematics education at KTH, have on the students' results and attitude?"* This main research question was partitioned into several smaller topics that are discussed below.

- **What grades are the students getting and is there a correlation between using the web-based tool?**

In order to find out what effect web based video lectures had on students' results at KTH, there was a need to investigate any correlation with student grades and website activity of Flervarreportalen. This had to be done with both qualitative data from interviews and questionnaire, as well as quantitative data from grade development and website statistics.

As the interview with Professor Cleveland-Innes, a short discussion with the lecturer responsible for the course (at KTH) and several studies revealed, student results are very difficult to analyze due to outlying factors, such as motivation, computer efficacy, etc. While questionnaire answers lacked in this regard, interviews processed these questions. Two of the four interviewees stated that they were generally confident in mathematics, but believed that Flervarreportalen had helped them achieve a better result. The two others claimed that the presence of a web based educational complement had given them a feeling of security.

With this in mind, grade development, questionnaire answers, interviews and website statistics were all combined and investigated for possible links or connections. With a wide spread of

grades among the 16 students in the questionnaire, there were no strong trends or connections that were clearly identifiable. Most students in this group had not used the site very much (averaging 4 login sessions total), and therefore it is natural to believe that it did not impact their results very much. The exceptions that occurred (students with 16 and 10 login sessions) both had completely different results (grade B and F), meaning that results in this regard were inconclusive. Also, as differences in previous individual math grades among the students were very small or nonexistent, that data was discarded as well. Lastly, as the grade development graph (Figure 9) lacked information about re-exams, it was difficult to give any answer to the above research question.

- **What user patterns and trends occur? E.g. do students log in at a certain time in relation to the course advancement**

As it was evident after the questionnaire that students had started using other educational channels in search for OER, the amount of login sessions that the statistics showed were very likely higher than reported. Several students had from day one fully replaced conventional lectures with other educational sites, while most active users on Flervarreportalen had at least logged in a few times before moving on to other educational sites after feeling that Flervarreportalen did not cater fully to their needs.

Another important point to make was that students who did not use the site much, still found it relevant and useful if they happened to miss a live lecture, or simply wanted to rehearse something. This is further supported by the website statistics where user activity peaks were observed during seminars and in rehearsing before the final exam.

The website statistics also reveal that the major part of user activity on the site was during the evening, meaning that students were able to watch a lecture during a time of the day when normally that was not possible. Dunn and Dunn and other research on learning styles agree that individuals need to have the opportunity to learn at their own pace and conditions. This increased flexibility would therefore cater to the needs of individuals with learning styles outside the norm of 08:00 - 17:00 school studying.

- **What role does the interface design and functionality design of the web portal play?**

As Professor Cleveland-Innes emphasized, implementation accounts for a huge part in the success of online education. While many users of Flervarreportalen thought the website was good, easy and streamlined, others complained about the lack of relevant videos and more advanced functions, such as chat (ability ask questions), a more visible and teacher-driven online lecture arrangement, and more. The lack of these functions and principles resulted in users leaving Flervarreportalen after a while in favor of more dedicated and well-stocked educational sites (such as MIT or Khan Academy directly). However, these users were still glad that

Flervarreportalen opened up their eyes for the additional material that is available out there. The problem was that their departure resulted in inaccurate website statistics for Flervarreportalen.

- **What are the students' personal opinions on using the system - how has it affected their motivation, results and confidence in mathematics?**

On a whole, students have been positive to the release of a web based learning platform for the course in Multivariable Calculus. Questionnaire responses reveal that many students felt comfortable knowing they had a site to fall back on, should they be sick or miss a lecture. As questions about confidence and motivation in mathematics were missed in the questionnaire, the interviews served as a guideline in this regard.

During the interviews, all four students revealed that they were positive about Flervarreportalen and OER in general, and two thought the site had directly affected their results in a positive way. Opinions varied on whether the web portal only should be a complement to conventional lectures, with one interviewee successfully replacing conventional lectures with OER during the course, while another interviewee considered the notion of studying on your own with only OER instead of conventional lectures detrimental to her motivation in studying mathematics altogether.

In website statistics it was obvious, as stated above, that users enjoyed the flexibility of being able to study when it suited them. This was also mentioned in the questionnaire, where students praised the ease of access and availability of an OER portal, when considered as a complement, not a replacement to conventional material. Even though users eventually left the site in search for more material, the maintained activity throughout the entire course of almost two months (as seen in website statistics) suggests that it was not a mere novelty effect that made students visit and use the site.

Whether or not the above points affected the results or not is difficult to speculate about, but they do imply that students have been enthusiastic about utilizing a web based mathematical resource; been glad that its resources have been available at their own terms, and after using it, searched the web for new, interesting OER to use in their studies.

7 Conclusion

7.1 Answer to our main research question

> *"What effect do web based video lectures, as a complement to mathematics education at KTH, have on the students' results and attitude?"*

There is qualitative data that suggests that students did use OER more than what was reported from Flervarreportalen, with interviewed students believing they achieved higher grades because of Flervarreportalen. This supports the belief that OER as a complement to mathematics at KTH did affect student performance in the course of Multivariable Calculus.

The problem is that the quantitative facts; grade and website statistics, do not support this belief. The usage of the site was too limited, and any visible correlation between student results and website activity could not be found. In addition, student results are very volatile when outlying factors are taken into account, and since this personal data was not investigated enough, it means that any potential connection discovered would be questionable.

However, feedback from students in the questionnaire and interviews revealed that many students were positive and relieved to having an educational web platform as "backup" in case of illness or other reasons preventing them from attending a live lecture. Many students expressed enthusiasm in being able to use the web platform on their own terms, and later went on to find additional, new OER on the web. Added flexibility in when and where to be able to study by using Flervarreportalen would cater to students with learning styles outside the norm.

In conclusion, a connection between the use of Flervarreportalen and student results could not be found with the obtained data. However, several points in this report indicate a positive effect on the students' mindset in mathematics, with increased confidence and comfort, and ultimately, a more positive attitude towards studies in mathematics.

7.2 Future research

This investigation has answered many questions and uncertainties, but also opened up for new ones. As OER is a relatively, yet, new area of study where advancements are made rapidly, further research is definitely of interest. Topics such as video length, outlying factors in student performance and visualization are aspects that could be explored additionally.

Student comments that emerged throughout this study were the diverse opinions on video length and how they affect the prospect of using a web tool such as Flervarreportalen. It would be interesting to examine how and why the lengths of video material influence the web tool usage and in that case what the ideal length of a video clip should be to minimize procrastination or lack of interest. Another recurring realization was the influence of outlying factors. Investigating personal factors and individual differences, which affect the way students learn mathematics

using OER would therefore be of great interest. As Skemp mentioned in his research, mathematics is an abstract subjects and learning could be made more effective through a visualization tool. The creation of such a tool would

7.3 The future of OER in mathematics and at KTH

There is no doubt that OER and distance education is a worldwide current topic of interest. The demand for web based educational tools is rapidly increasing, and universities and institutions are competing in offering the most expansive range of open courseware (Wallström, 2012).

The results obtained through this investigation suggest that the students of KTH are prepared for this technological advancement. In Mathematics specifically, the seed has already been planted, as a result of Flervarreportalen as well as the students' own curiosity. Nevertheless, a successful method of implementation needs to be established for the tool to fulfill its purpose of improving results and offering students better self-confidence and a more positive attitude towards mathematics.

> "Online education is here to stay, and it's only going to get better"
>
> - Lawrence S. Bacow, 2012, past president of Tufts University, member of the Harvard Corporation

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Appendix I - Questionnaire questions

* Required

Vad är din KTH-mail (eller KTH-id)?
Det vore jättebra för oss att kunna matcha enkätsvaren med respektive inloggad person på hemsidan. Vi kommer inte delge någon din information eller spamma dig :-)

Hur ofta har du använt www.flervarre.se? *

- ○ < 1 gång/vecka
- ○ 1-3 gånger/vecka
- ○ 4-6 gånger/vecka
- ○ > 6 gånger/vecka

Hur många föreläsningar har du gått på? *
BARA föreläsningar inte seminarier, övningar etc.

- ○ 31-41
- ○ 20-30
- ○ < 20

HUR har du använt www.flervarre.se? Om inte alls, varför? *
Exempelvis: inför föreläsningar/seminarier, pga sjukdom?

Har du hoppat över schemalagda föreläsningar på KTH pga www.flervarre.se? *

- ○ Ja
- ○ Nej

Om du svarade "Ja" på frågan ovan, förklara varför!

Har du någon synpunkt om funktionerna på www.flervarre.se? *
Saknas något? Något som kan förbättras?

Övrig synpunkt *
Exempelvis: har www.flervarre.se hjälpt dig, gjort dig mer stressad, etc.?

Skulle du kunna tänka dig att ställa upp på en 15 min intervju? *
Vi bjuder på fika :-)

- ○ Ja
- ○ Nej

Appendix II – Interview questions

Interview questions with Martha Cleveland Innes

Is there a noticeable difference in mathematics grades between students who attend live lectures and students who only attend distance education?

What is your impression when it comes to students' attitudes towards distance mathematics?

What is your impression on the general opinion on distance learning/OER?

How important is the design of the web tools for student performance?

What user patterns do your students have - for example; do they study from 8 am to 5 pm? Are there any problems/benefits from this?

Is there more procrastination amongst online users than in traditional classes?

What do you 'miss' from traditional classes that you don't get from online lectures?

Vice versa, what do you think is good about online lectures compared to traditional classes?

Do you think OER and online learning tools should replace or complement traditional teaching? Or is it just a 'necessary evil'? Why?

What do your students feel about using OER and e-learning? Negative/positive feedback?

What about social interaction? Do students miss this and has the lack of it any effect on learning?

What is your personal opinion on e-learning and OER?

Student Interview question outline

Hur många föreläsningar har du/ni gått på? varför?

Traditionella vs. Online föreläsningar?

Har du/ni använt flervarre.se?

Varför?

Hur? Ex. bara när man råpluggat inför tenta, i hängmattan när man ändå inte haft något annat för sig, etc.

Plattform?

Vad behövs för att studenterna ska tycka flervarre.se är bättre?

Kan man utforma hemsidan så att det fungerar som ett komplement och inte ersätter traditionell undervisning?

Åsikter om www.flervarre.se. Funktioner? Design?

Hur har din/er attityd mot matematik förändrats pga www.flervarre.se?

Känner du/ni att studerandet generellt sett blivit svårare/enklare pga flervarre.se? Ex. prokrastinering, bra om man är sjuk, etc.

Betyg påverkan?

Övrigt