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Abstract

Improved access to technology has led to an increase in the number of online courses and degree programs in higher education. Despite continuous progress, little attention is paid to 'understanding' students prior to implementation of learning and teaching processes. Being a valuable input for design of online learning environments and student satisfaction, its neglect may result in frustration and resistance by students. This study focused on investigating preferences of on-campus engineering students to contribute designing a fully online calculus course in a Turkish university. A qualitative design was used to achieve in-depth information about students' reflections on online calculus sessions. Findings opened the floor for discussion about must-have characteristics of online learners, orientation of on-campus students to online learning environment, challenging nature of mathematics as a discipline to be taught online, and the necessity of considering human and instructional perspectives in online learning rather than following a mere technological path.

Introduction

Improved access to information and communication technologies, along with the advantages they have brought to educational environments in recent years, have led to a dramatic increase in the number of online degree programs provided by higher education institutions, as well as the integration of online technologies into on-campus degree programs. Online degree programs are mostly preferred by adult learners who have not been able to access conventional education due to several reasons including, but not limited to, socio-economic issues, cultural restrictions or physical disabilities. Bricks-and-mortar universities also offer, and encourage faculty members to open online courses (or technology-supported courses) not only for pedagogical, economic or logistical purposes, but also for providing flexibility to students in terms of time, space, and access to learning materials.

In the US, recent data from the Integrated Postsecondary Education Data System (IPEDS) of the National Centre for Education Statistics show that more than 70% of all currently active, degree-granting institutions have some distance offering. According to the European University Association's 2014 report on E-learning in European Higher Education Institutions, which reveals the findings from a survey conducted with 249 higher education institutions and 38 European systems, most of the respondent institutions have integrated e-learning into conventional teaching and use blended learning (91%), and a surprising number of institutions (82%) offer fully online learning courses. In Turkey, both public and private higher education institutions have also embraced web-based distance education, either in the form of fully online degree programs or delivery of online classes for on-campus students, particularly for core subject courses.

Nevertheless, despite this continuous progress of online learning, little is known about what makes students enroll to online courses or programs, or what their preferences and expectations are from online learning environments (Arinto, 2013; Koper, 2015). Naidu (2013) also emphasizes inefficiency of the attention paid to 'understanding' students and their concerns prior to implementation of learning and teaching processes, which may provide valuable input for proper design of online learning environments and for the satisfaction of students. In this regard, neglect may result in frustration and resistance to the use of online learning by students, which may in turn deter from effective learning.

This study focuses on analyzing perspectives and opinions of engineering students about online learning during a pilot implementation of a core subject course before going fully online. Besides online higher education

institutions or online degree programs, online courses offered by bricks-and-mortar universities to on-campus students have proven to be surprisingly popular. Today, at many universities, students are given the opportunity to take online courses in addition to their on campus classes in order to fit their course program to their responsibilities and priorities. According to 2010 survey results by the US Conference Board of Mathematical Sciences, 35% of four-year mathematics departments offers online courses of which 72% is fully online (Blair, Kirkman, & Maxwell, 2013). Moreover, Trenholm refers to Kirkman and colleagues' previous survey indicating a 300% increase in the university distance education course enrolments in Calculus I from 2000 to 2005 (Kirkman, Lutzer, Maxwell, & Rodi, 2007 as cited in Trenholm, 2013). Nevertheless, teaching mathematics online, or more generally at a distance, is a controversial issue discussed by many researchers for decades. Freudenthal (1991) discussed that mathematics is 'learned differently and therefore should be taught differently' (p.11). Although mathematics has been considered as a discipline closer to technology mediation, some researchers describe mathematics as one of the most challenging and difficult disciplines to be delivered online (e.g. Engelbrecht & Harding, 2005; Glass & Sue, 2008; Lokken, 2011). Yet, design of proper digital tools with pedagogical potential, as well as a strong instructor presence and creation of the required educational context in view of learners' needs are emphasized as crucial factors for the successful use of digital technologies in mathematics education (Drijvers, 2012).

Calculus is a baseline course starting for undergraduate engineering sciences. Engineering students have to be competent in mathematics in order to understand and explain many concepts in their field. There are several studies in the literature indicating that technology use in calculus courses, whether it is the use of a software or program in a face-to-face course or use of online technologies in a fully online or blended course, an improvement in communication skills, motivation and achievement of students (e.g. Allen, 2001; Cerri & Bonomi Barufi, 2003; Kinnari-Korpela, 2015; Majid, Huneiti, Al-Naafa & Balachandran, 2013; Young et al., 2011).

Simonson, Smaldino, and Zvacek (2015) draws attention to a seemingly contradictory issue: "students prefer to learn in a classroom, but demand to be permitted to learn at a distance" (p.5). Hence, students prefer meeting with instructor and their classmates in a physical space and experience physical interaction per se, yet they want to be able to study when and where they wish. Flexibility and convenience are two significant features of online learning (e.g. Ally, 2004; Anderson, 2004; Cole, 2000). It is this temporal aspect that provides a huge advantage, particularly for non-traditional students; nonetheless, it comes with a price. Online classes require much more discipline, academic ability and hard work than most on-campus classes (Cerri & Bonomi Barufi, 2003; Simonson et al., 2015). Not everyone is set for such independent, self-paced learning, and while numerous learners prefer to study at their own tempo, many others still choose and feel more comfortable with a more structured learning experience (Koper, 2015). Yet, online learners should be independent, autonomous, self-regulating individuals, who take responsibility for their learning and actively engage in the learning process (Broadbent & Poon, 2015; Wang, Shannon, & Ross, 2013).

Learner autonomy has been acknowledged as a key element of academic achievement by several researchers (Holmberg, 1995; Kearsley, 2000; Keegan, 1996; Peters, 1998). As Lynch and Dembo (2004) also points out, it is crucial to understand how autonomous learners function in online learning environments to ensure design and implementation of successful and high-quality online teaching-learning processes. Being one of the main pillars of Bandura's social cognitive theory, self-regulatory capability is considered to provide a framework to apprehend this functioning. Bandura (1986) says, "[s]elf-regulatory capabilities require tools of personal agency and the self-assurance to use them effectively" (p.435). Self-regulation is basically the ability of controlling one's own behaviors or responses to external stimuli. Being a very human characteristic, self-regulation allows individuals to self-observe their behaviors, assess, judge, and direct these behaviors in line with personal performance standards, and employ appropriate strategies for achievement (Bandura, 1977). According to Bandura, self-regulation is strongly dependent upon self-efficacy beliefs. He defines self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (1986, p.391). It is a person's judgment, belief or perception of one's self about the capacity or ability to handle various challenging situations and to successfully perform a specific action (Bandura, 1977, 1986).

Even though the number of online courses offered by conventional universities to on-campus students has increased rapidly, little is known about students' expectations and experiences. Hence, the aim of this research was to obtain a general view of expectations and preferences of engineering students for online learning. Students' opinions were obtained to identify potential issues related to e-learning in the form of self-report, and to contribute to the design of a fully online calculus course for on-campus students.

Method

Research Design

This study followed a qualitative design in the sense that it aimed to provide in-depth information about undergraduate students' reflection on online calculus sessions (Creswell, 2005). It was designed as a descriptive case study to understand a real-life phenomenon and clearly depict perspectives and expectations of freshman engineering students about online learning through self-report. Case study is defined as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially the boundaries between phenomenon and context are not clearly evident" (Yin, 2009; p.18).

Settings and Procedure

The study was conducted at the Faculty of Engineering of a public university on the west coast of Turkey. The first author is a mathematics educator, who has been teaching calculus face-to-face for five years, and has an online teaching certificate issued by the university's Distance Education Centre. Following the university's decision to deliver common core courses online for on-campus students, the researchers planned to study potential issues through self-reports from students in order to properly design an online calculus course. The course was re-designed as a hybrid course, based on the nature of weekly topics to be discussed, with eight weeks conducted face-to-face in the classroom and six weeks at a distance. The instructor carefully selected specific weeks with strong visual content to be delivered online for optimum benefit from technological tools and applications that might not be practical or possible to use in traditional classroom. Table 1 provides the outline of the course plan for the relevant semester.

Table 1.Course outline

	Subject	Delivery Method
Week 1	Derivatives and applications of derivatives	Face-to-face
Week 2	Antiderivatives, Integrals: The Area Problem, The Definite Integral	Face-to-face
Week 3	Properties of the Definite Integral, The Fundamental Theorem of Calculus	Face-to-face
Week 4	Indefinite Integrals	Online
Week 5	Applications of Integration: Volumes	Online
Week 6	Techniques of Integration	Face-to-face
Week 7	Improper Integrals	Face-to-face
Week 8	Infinite Sequences And Series	Online
Week 9	Convergence Tests for Positive Series	Online
Week 10	Alternating Series	Face-to-face
Week 11	Power Series, Taylor and Maclaurin Series	Face-to-face
Week 12	Taylor Polynomials and Taylor's Formula	Face-to-face
Week 13	Applications of Taylor Polynomials	Online
Week 14	Multiple Integrals	Online

Course materials included course notes prepared by the instructors, presentations, exercises, worksheets, animations, web links, and tasks. All materials were uploaded to the course management system of the university created using Moodle (acronym for Modular Object-Oriented Dynamic Learning Environment), an open source software learning management system used to create personal learning environments for online or blended learning or other e-learning projects in educational institutions. Virtual classes were held via Adobe's web conferencing software (Adobe Connect), where the instructor used dedicated studios at the university equipped with a smartboard and sensor-motioned camera. Virtual classes were automatically recorded, and added to the course page as easily accessible for students. Figure 1 provides screenshots from course page and virtual classes. The instructor had an orientation week at the beginning of the semester, and using the course page, refreshed students' knowledge about the use of the course management system, and how the course would be conducted step by step.

Participants

Participants of this study were 88 freshman students taking the Calculus II course as part of their four-year bachelor degree program in the departments of civil and computer engineering of a public university in Turkey. At the beginning of the spring semester, 52 civil engineering students and 36 computer engineering students

were informed about the purpose and methodology of the study. This was repeated at the beginning of each virtual class throughout the semester. Having been duly informed about their anonymity and the voluntary nature of the research, all students gave their consent to participate in the study on voluntary basis.

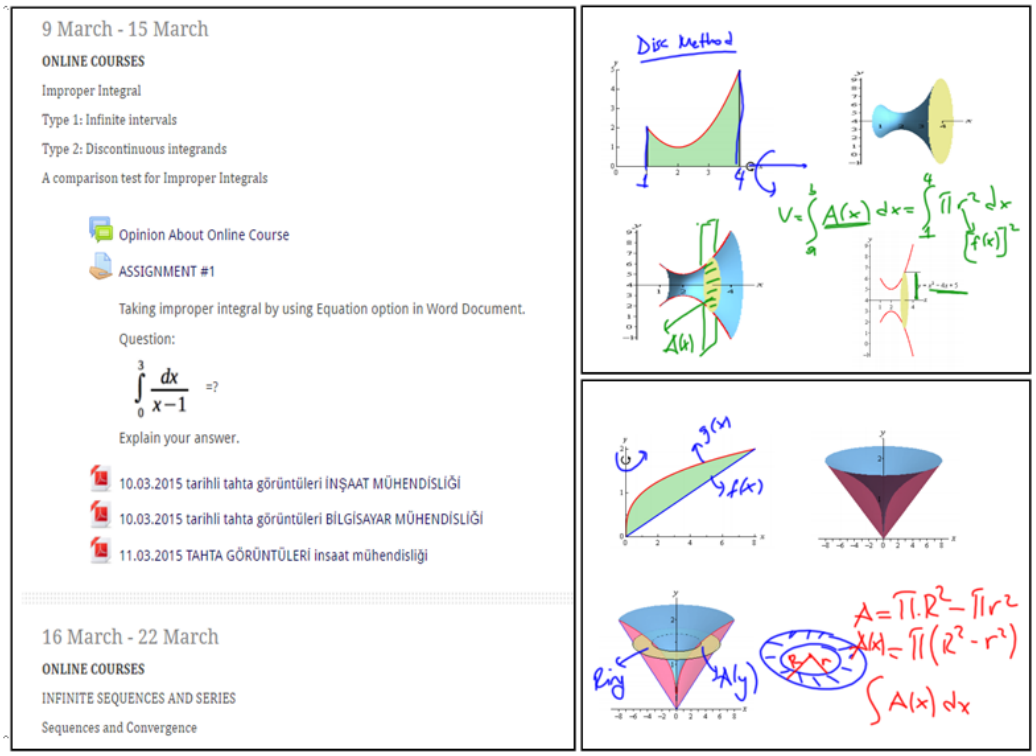

Figure 1. Screenshots: Course page and smart board

Data Collection

Questionnaires are useful data collection tools to learn about the distribution of characteristics, attitudes or beliefs (Marshall & Rossman, 1999). They help researchers make critical assumptions about a group of participants so that characteristics or beliefs can be described or measured accurately through self-report. Using questionnaires, we rely on the honesty and accuracy of the participants' responses as we do for many tools in research.

At the end of the semester, students were provided a written questionnaire which comprised of six open-ended questions (Appendix 1). The questions aimed to reveal opinions and perceptions of students about the course in general along with a self-report on their own performance in the classroom, instructor's performance, operation of online sessions, and perceived advantages and disadvantages of the use of online technologies to create blended learning environments. Students responded to the questions in a 15 minute face-to-face session. In order to receive the most honest and accurate answers to the questions asked, the aim of the study was carefully explained to the students at the start of the semester at the very first session in the classroom. As a result, students were fully aware of the data collection procedure, and how important their answers would be to the questions.

Data Analysis

Responses were transcribed, and uploaded to MAXQDA11, a professional software used for qualitative data analysis. The responses were read line-by-line, and a bottom-up, data-driven analysis was conducted. Firstly, two researchers individually coded a group of data selected randomly from the data set, which led to 87% reliability between researchers based on a "100 x consensus (consensus + dissension)" formula. Difference between the coders was overcome, and consensus over codes were reached upon a joint session with the data. Then, the data were broken down into discrete parts, closely examined and compared for similarities and differences (Strauss & Corbin, 1998). After completing line-by-line coding, the important concepts and

categories were constructed through the themes. Thematic content analysis was used to analyze data. Defined as "a method for identifying, analyzing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p.6), thematic content analysis is a descriptive presentation of qualitative data through identification of common themes in the texts provided for analysis. The next step, then, was to define the unit of analysis to be classified during the thematic content analysis (Zhang & Wildemuth, 2009). The unit of analysis in this study is a fragment of meaningful text that might include a partial or a single or several sentences uttered by students about online components of the Calculus course. Eventually, certain concepts were grouped under four higher order concepts: Temporal Matters, Barriers to Online Learning, Preferences for Online Learning, and Teaching Process. They are themes of this study constructed on the basis of previous literature and obtained data (Akdemir, 2008; Lee, 2014).

Findings

This section commences with an explanation of the nature of the themes, and continues with direct quotations from the participant students. These excerpts illustrate students' opinions, feelings and thoughts about the online calculus course, and implicate their preferences and perspectives of learning online in general. Excerpts from students' responses are translations by one of the authors, who is bilingual. Finally, we describe results from our search according to the thematic content analysis for relevant patterns (i.e. parts of the experiences common across all participants).

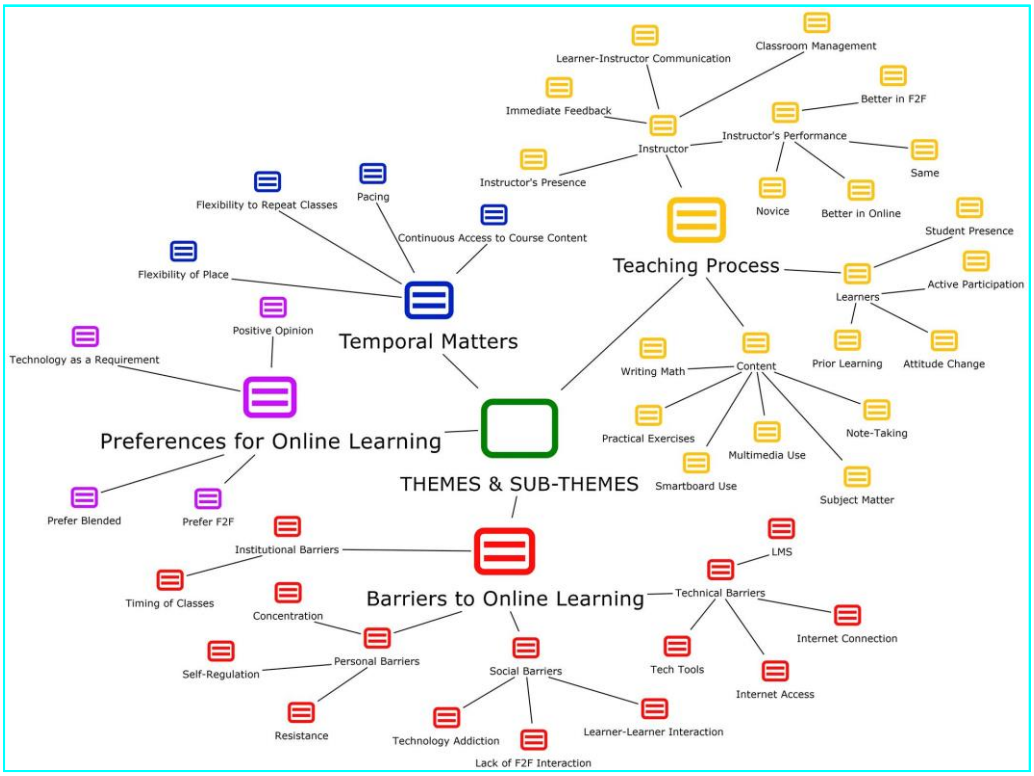

Figure 2. Map for themes and sub-themes

We found 635 codes from the thematic analysis, which were then distributed into four themes (Appendix 2): Temporal Matters, Barriers to Online Learning, Preferences for Online Learning, and Teaching Process. Figure 2 illustrates Appendix 2 to enable a pictorial summary of main themes and related sub-themes.

Temporal Matters

Time is an important factor to consider in online learning and teaching affecting students' learning, understanding and feelings (Romero & Usart; 2014). In data analysis, students' perspectives and opinions for temporal aspect of online learning were classified under four sub-themes. Figure 3 shows frequencies and relevant percentages for each connected sub-theme.

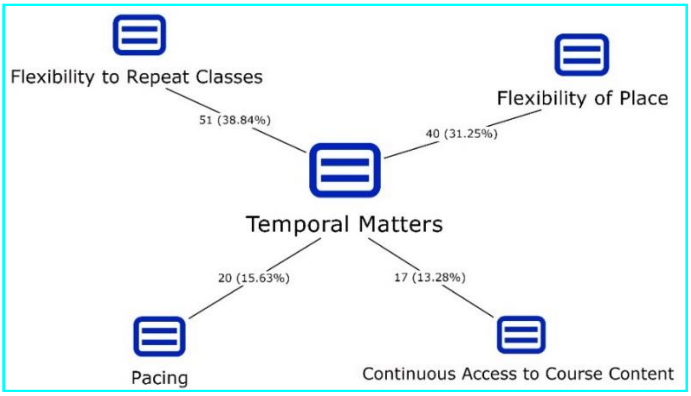

Figure 3. Map for temporal matters with frequencies

Figure 3 shows dissemination of total 128 coding under temporal matters theme as of sub-themes. Flexibility to repeat virtual classes was mentioned most often by students with 39% of the codes classified under this sub-theme. Even if they were not in favor of online learning, students emphasized the advantage of being able to watch or re-watch recordings whenever and wherever they wished, fundamentally due to attendance problems or for better comprehension of the subject.

CivilEng#18: It was also good to watch video recordings again…

Another sub-theme highlighted is the flexibility of place with 31% of the codes. Considered in parallel with the flexibility of time, this sub-theme indicated a considerable emphasis placed by students on the mobility that online learning provided. Students very much valued to be able access classes at any time and from any place such as home, dormitory or even a café. They considered this as a kind of 'time saving' since they believed that traveling to campus from a relatively distant place was time consuming, and by online connection to the class they would have extra time for themselves.

CivilEng#38: Studying from home is really wonderful.
CompEng#55: Connecting from home is an advantage, if you ask me, it is comfortable…
CompEng#66: No need to travel to access knowledge. It [online classes] provided opportunity and comfort.

This 'comfort', however, was considered as distracting by some students since it was easier to lose focus and drift towards other tasks, particularly on the Internet. Students, in 6% of the codes, stated that they had difficulty to concentrate on the lecture, and could not manage their time properly. Some students regarded this comfort as an 'insolence' to the nature of the course ("Mathematics is too important to be taught online") because teaching of mathematics required a 'serious' learning environment with the physical presence of the instructor.

CivilEng#5: It was hard to concentrate on the class because I connected from home.
CivilEng#8: I was more relaxed, so I squandered. I connected from home, wearing comfortable clothes. Many times I turned volume down, and surfed on the Internet. It was similar for my friends as well.

Pacing is another concept with which many students struggled. About 16% of the codes under temporal matters was related to pacing. They mostly complained about the quick pace of virtual classes where the instructor was too fast to keep up with the topic or to take notes in detail. Some stated that this was due to a lack of face-to-face discussions or recitation sessions between the instructor and students over subjects, as would occur in a physical classroom environment.

CompEng#78: Professor's classroom management is very good, but the pace of the class is very fast when it is online.
CivilEng#5: Pace is faster in online classes because the instructor cannot get individual reactions from the students.

In addition to the flexibility to repeat virtual classes, continuous access to course content is another key characteristic of online learning allowing for freedom from time and space. Being able to access lecture notes as well as smartboard writings through LMS was also valued by the students with 13% of the codes focused on

continuous access. This was particularly emphasized by students who had an overlapping class or who complained about the fast pace of virtual classes.

> CompEng#58: For example, I can go to the previous week's course notes and repeat the recordings with PDF files [of the course notes].
> CivilEng#40: It provides advantage for accessing course notes … especially for people having difficulty in finding notes because they have an overlapping class.

Barriers to Online Learning

Barriers to online learning is another theme taking on several concerns of the participant students causing them to sidestep from learning online. Obstacles or problems stated by students were classified under four sub-themes. See Figure 4 which shows frequencies and relevant percentages for each connected sub-theme.

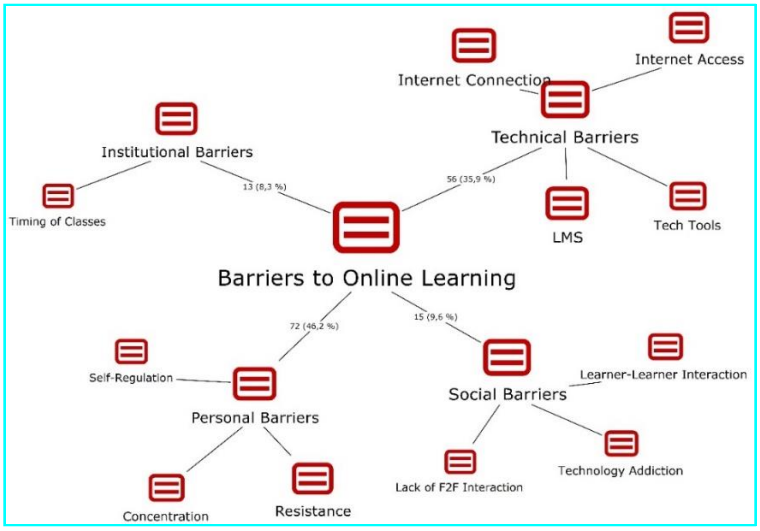

Figure 4. Map for barriers to online learning with frequencies

Almost half (46%) of the codes under barriers theme focused on personal barriers. Personal barriers cover several concerns by students, ranging from lack of motivation or concentration due to distraction by technology, to conventional learning habits. Under the personal barriers, difficulty to concentrate and lack of focus in classes was the most cited worry by students with 44% of the codes centering on concentration. The professed advantage of time and space flexibility in online learning was, in fact, specified as a major disadvantage by many students because they were easily distracted by external stimuli such as social media, television, online games or the Internet in general, when connected to classes from anywhere other than a classroom with the physical presence of an instructor. Attention control is one of the most cited reasons for negative opinions by participant students.

> CivilEng#5: There are many distracting factors in a comfortable environment … if I cannot concentrate on the class … like telephone, Internet, etc.
> CompEng#57: I connect to virtual classes from home, but I cannot concentrate as in the normal classroom because home is more comfortable.

Some students, on the other hand, considered this flexibility as a plus that allowed them to concentrate better to the classes in a more private environment rather than a classroom. Ratio of positive codes for concentration attributed to 11% of the codes under this sub-theme.

> CivilEng#44: I felt like it was a private course where the professor was tutoring only me. This made me concentrate more.
> CivilEng#14: I concentrated on the class more easily because there was only the professor's voice. I think my performance was higher.

Statements of some students showed a great degree of resistance to the use of online learning technologies for a calculus course with 6% of the codes focused on this issue. These students mainly felt 'threatened' by change,

which these technologies bring about abruptly to their accustomed in-person classroom environment, they felt alienated, and they resisted (or some even rejected) it.

> CivilEng#18: I felt alienated because the subject matter was difficult and I could not understand as well as like this [online].

Technical barriers are quite important in terms of accepting technology integration in education. Technical barriers include having access to computers or certain applications, Internet access, fast Internet connection, and technical support. Technical barriers covered 36% of the codes under this theme. Accessibility advantage of online learning was emphasized by some students as a barrier since they had to go to a café to join virtual classes due to the lack of a home computer or Internet access. Although rarely experienced, technical problems regarding the LMS caused interruptions during virtual classes.

> CompEng#53: Sometimes, there were problems in the system or with the Internet.
> CompEng#82: If I didn't have Internet connection at home, it would be difficult to connect from a café.
> CompEng#70: All systems did not play Flash applications, this created problems. Also, sometimes, there was problem in receiving voice or a lack of synchronicity between sound and video.

Ten per cent of the codes concentrated on social barriers, under which interaction has a major place. Interaction is a significant factor in student satisfaction. Students wish to be in personal contact with their instructors, both in the classroom and during office hours. Although on-campus students have the opportunity to personally meet their instructors in non-teaching hours, lack of such personal interaction in virtual classes is considered to be a major drawback for students regarding online learning. Communication merely through text messages or even real-time chats in virtual classes does not feel like communicating in real terms:

> CompEng#66: I think interaction and communication is missing because we can only contact the professor with text messages.

Real-time chats in virtual classes is described by some students as 'distracting' since some may prefer chatting with each other on different, irrelevant subject matters during the class.

> CivilEng#2: Chat area is sometimes used for chit-chat. This distracts me.

For the purposes of this study, statements about learner-instructor interaction is classified as a social barrier to online learning. Social barriers also include issues about learner-learner interaction.

> CivilEng#45: Communication is only text-based. That's why we can't have interaction with our classmates. This is the only disadvantage of this course.

Technology dependency and Internet addiction is another concern considered under social barriers, with 13% of the codes under social barriers dedicated to addiction. Already spending too much time with technological tools with an Internet connection, some students think that having classes online will cause them to use technology and make them addicted even more.

> CompEng#69: It may be a disadvantage [of online courses] that technology-addicted youth is dragged to more technology across all environments.

Students' concerns about the timing of classes are reflected as an institutional barrier. Of all codes, 8% focused on institutional barriers. There are two main issues highlighted by students under this sub-theme. One is the early hours some classes are set for, and since they have flexibility to join in virtual classes from home, they generally fail to discipline themselves for early classes and simply cannot concentrate in the relative comfort and relaxed atmosphere of their homes. The other issue is again related to timing of the virtual classes. Since the participants are on-campus students, most of their courses are face-to-face. If their online courses are placed between two face-to-face courses, or their face-to-face course starts immediately following an online course which they join from anywhere other than a lab at the university, they miss one of the courses. This is an institutional barrier, which should be handled with care by the relevant department when designing weekly course programs.

CompEng#57: I have difficulty in catching the following class.
CivilEng#29: It is difficult to catch the following course if one accesses from home or the dorm.

Preferences for Online Learning

One open-ended question is directly related to the preferences and any other opinions of the participant students. They mainly stated their preferences for taking calculus online/blended or purely face-to-face (Figure 5). Some had very positive opinions about online calculus, yet others mentioned technology as a requirement that we have to keep up with.

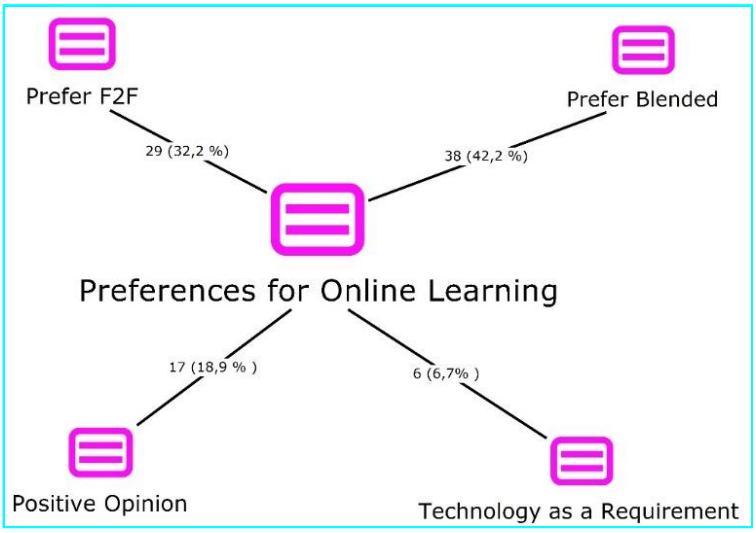

Figure 5. Map for preferences for online learning with frequencies

About one-fifth of all codes focused on positive opinions by students about taking this class using online technologies. Novelty of online technologies was emphasized by the students. They underlined the importance of keeping up with innovative technologies:

CivilEng#34: I think it [online course] was very efficient for me.
CompEng#59: We should keep up with the globalizing world. We have this opportunity, so why don't we use it? It is good for future generations because they are more familiar with technology.
CivilEng#50: I am not good at using technology, and I don't know much about using computers. Having an online course helps me to improve myself. I'm also trying to type faster to participate in classes.

Due to the previously mentioned personal, temporal and institutional barriers, some students prefer a face-to-face learning environment for calculus, with a focus by 32% of the codes. Old habits of learning in a classroom with the physical presence of an instructor lecturing while students are taking notes, non-familiarity with technology, inability to effectively use a keyboard and preconceptions about using technology for a critical course like calculus, have led them to prefer a face-to-face learning environment.

CompEng#57: Even though using technology is efficient, I prefer having Calculus face-to-face in the classroom.

Despite this preference for a face-to-face learning environment, that 42% of the codes concentrating on blended environment indicated an appreciation of the use of online learning technologies to support classroom activities by a considerable amount of students. The concept of a blended course, where they could spend the theoretical part in the classroom through lectures and discussion supported with online recitation hours, was relatively attractive to them.

CompEng#55: I think we should have theoretical subjects in the classroom face-to-face, but graphical subjects in online classes.

Teaching Process

The most cited issue by the students is the nature of the course, and suitability of delivering a mathematics class online. This is both due to the perceived weight of the course, and to using so-called 'trivial' technologies for such an essential course, as many said. Difficulty to use the language of mathematics in writing, both for setting and receiving tasks and homework online, or using real-time chatroom of the virtual classroom, was also another concern connected to the nature of the subject matter. Students' statements were grouped under three sub-themes under the main theme of teaching process (Figure 6):

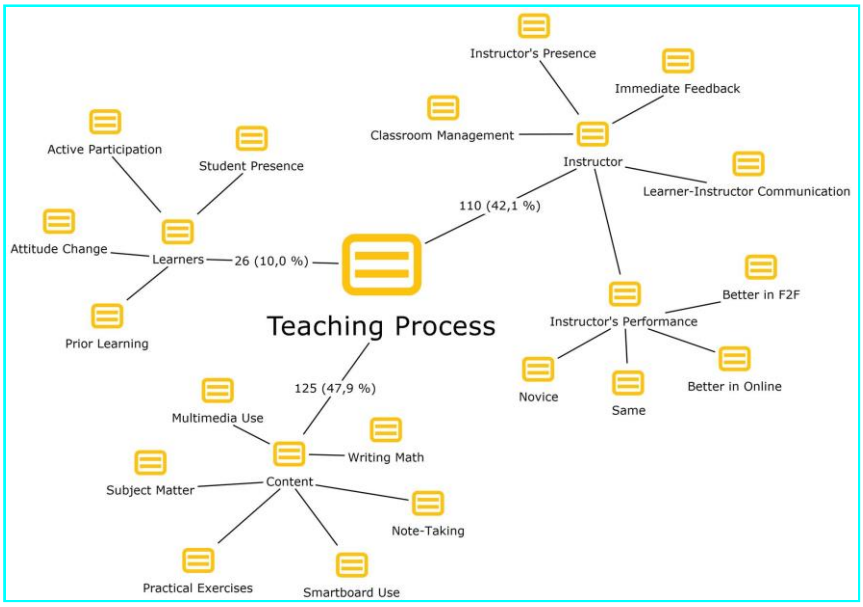

Figure 6. Map for teaching process with frequencies

Content was a major sub-theme under Teaching Process, in which students underlined the use of a smartboard and other multimedia tools, as well as their concerns about the application of practical exercises, note-taking and writing mathematical concepts in online learning environments. About half of the codes (48%) focused on content.

As briefly mentioned above, students mostly complained about not being able to write mathematical symbols both in virtual classes for real-time chat purposes. When the instructor asked a question about a topic in the virtual class, students could not answer because of this reason. This is mainly due to non-familiarity with the system, as well as a lacking of certain competencies of some students. Statements showed that students also lacked basic computer skills using certain word processing software. Regarding tasks or homework involving integral or other mathematical symbols, they also complained about writing mathematical symbols, although software such as Microsoft Word or Latex had special tools for writing formulae and/or mathematical symbols.

> CompEng#53: Online tasks are difficult. It would be better with paper and pencil. It is hard to solve them and send it through the Internet.
> CivilEng#46: It is difficult to write all formulae and symbols using computers. I even had difficulty in writing them in Word, and it was very slow.

Note-taking, still, was a multifaceted issue for the students. Some students were quite content with the use of a smartboard in virtual classes since they were able to access electronic version of all notes on the board. Some, on the other hand, were very conventional about note-taking, and wished to write down their own notes like they were listening to a lecture in a traditional classroom. Yet, they stated that they could not concentrate in front of the screen, they lost track of the course of the lecture, and failed to take notes.

Using a smartboard and illustrating abstract topics using multimedia is very attractive, not only for students, but also for the instructor. Interactive graphs, figures, animations and simulations, which could easily be used on the smartboard, were said to make the class more attractive and clearer to understand.

CompEng#55: Graphics and shapes are more understandable. I can remember solutions later more easily.
CivilEng#45: Smartboard made this class more interactive and more creative.
CompEng#55: Lecture was more understandable for shapes and graphics. Topics with graphics should be taught online.
CivilEng#22: Course topic was good because the professor could show us examples online and the figures were precise.

Using a smartboard for practical exercises and solving problems is considered to be another advantage of online classes, since they can follow it better on the screen and they can access the electronic version of exercises whenever they wish. In parallel with preference for a blended course, some students suggested having theoretical part of the course in the classroom, face-to-face, with the physical presence of an instructor lecturing, and recitation part online.

CivilEng#22: I think I feel good when the professor solves examples online.
CompEng#81: I want to see recitation sessions online.

This may be highly related to the 'grave' importance attributed to the course. This is the most cited issue by the students: Calculus is a very important course for engineering students, and they associate online courses more with so-called 'superficial' or 'trivial' core subjects like language or social sciences. They do not think it is suitable to deliver such a fundamental course online. Being one of the essential subjects of the engineering curriculum, it should be taken seriously and taught face-to-face in a classroom environment.

CompEng#54: Online calculus is inconvenient because mathematics is a very important course.
CivilEng#30: Online classes are good for courses less demanded by students (e.g. Turkish language, computing).

Instructor is the second sub-theme of the teaching process, with 42% of the codes, under which there are five strands appeared: classroom management, learner-instructor communication, immediate feedback, instructor's performance, and instructor's presence.

Students judge classroom management as in managing a face-to-face classroom, and expect strict control by the instructor. In their opinion, instructors should be fully in charge of the learning environment through continuous controlling, directing, commanding, and supervising them, and they expect their instructor to exhibit the same behaviors and control in the online learning environment in the exact same manner. Without the presence of such an authoritarian control, due to the nature of virtual classes, they fail to regulate their learning and blame online technologies for their distraction and even their own under-achievement. This brings us back to the aforementioned characteristics of online learners being autonomous, self-regulating, self-directing individuals with a certain academic maturity.

CivilEng#50: [Professor cannot maintain control if] students enter the virtual classroom but open new tabs and pretend that they're listening.
CivilEng#21: Some of my classmates enter the virtual classroom but do not listen to the lecture. They minimize the page, and either play online games or hang around the Internet.

Students' opinions also differ for communication with the instructor in online learning environment. Some students were quite enthusiastic about communicating with the instructor in the online learning environment. They said they could ask whatever questions they had in mind via real-time chat during virtual classes, and received immediate feedback from the instructor. Another group of students, on the other hand, was not very comfortable with the use of real-time chatroom since they could lose track of what was written due to the flow of other students' messages, which impeded their own communication with the instructor. Hence, they preferred the availability of microphones to directly communicate with the instructor in virtual classes.

CompEng#58: It is good that [professor] asks questions to receive feedback [from us]. Anytime, she can ask questions.
CompEng#64: A couple of times, I tried to ask questions but had to delete them because of lapse of time. Maybe, using a microphone can help us to fix this.
CivilEng#31: We don't have an opportunity to ask all the questions because when we type our questions, they may get lost among other questions [typed by other students].

Students additionally assessed the performance and presence of the instructor in virtual classes. Some measured the instructor's performance by comparing face-to-face and online classes as better, same or worse; here, half of the students stated that the instructor performed 'just as good as' in the classroom environment. Some students also underlined specific actions and activities by the instructor in virtual classes, and assessed the instructors' presence through questions posed to students, immediate feedback given to students, and the use of multimedia tools. Instructor's active presence in virtual classes was mainly emphasized by students with positive standing towards online learning technologies.

> CompEng#59: Our professor reflected her energy to us as if she was there in the classroom. Her performance was superb.
> CivilEng#5: Our professor's good management of these online classes is an important factor for this good experience.

Some students approached this experience from a learners' perspective reflecting on prior learning, attitude change, active participation and presence. Only 10% of the codes concentrated on learners. Students with prior knowledge of the subject matter (i.e. retake students) or of online technologies felt more comfortable with online classes, and adapted themselves better than others.

> CompEng#62: Online classes didn't affect me negatively since I had basic information about the course.

There were several students, who were rather opinionated about online learning, yet changed their attitudes during the course of virtual classes. Along with other statements, this gives a clue that students have only partial information about online learning. As will be discussed in the conclusion section, there is clearly a need for orienting and introducing the use of online technologies.

> CivilEng#14: I had my concerns [about online learning] at the beginning, but I started to think it was very appropriate during the first online lesson.

Some students stated that they participated in lectures and class activities more dynamically in online classes. They felt more comfortable with asking questions at a distance or enjoyed the benefit of re-watching class recordings.

> CompEng#77: I was more active in online classes. I used to immediately ask questions when I didn't understand a topic, and I can repeat the whole lecture again and again if I still have questions in my mind.

When students are more comfortable with and active in virtual classes, they have a more positive attitude towards the methods used in class that, in turn, results in a more active involvement in teaching and learning processes.

Discussion

There are numerous studies in the literature which endorse e-learning as an effective way to engage learners with learning (Lewis & Allan, 2005; McConnell, 2006). Then again, Naidu (2013), underlines the prominence of understanding learners along with their apprehensions as a valuable input for a proper design of online learning environments and for the satisfaction of students, the neglect of which may result in frustration and resistance to the use of online learning. Hence, this study focused on investigating expectations and preferences of on-campus students for online learning; with a primary aim to contribute to the design of a fully online calculus course for the faculty of engineering of a conventional university. Reflections of the students led to more than 600 codes classified under four main themes: Temporal Matters, Barriers to Online Learning, Preferences for Online Learning, and Teaching Process.

Flexible vs Conventional

One significant benefit of online learning is considered to be the flexibility of time. Flexibility to repeat virtual classes and continuous access to course content provide learners with freedom to choose where and when to learn. This is one of the most cited advantages of online learning by the participants of this study, regardless of

their positive or negative stance, fundamentally due to attendance problems or for better comprehension of the subject. Flexibility of place, on the other hand, is a multifaceted concern for the participants. Mobility to access classes from any place is considered 'time saving' and 'comfortable'; yet, this 'comfort' has also been distracting for some students since it causes losing focus and concentration on the lecture. This finding has taken us to question the concept of self-regulation of learners in experiencing online learning.

Being a very human characteristic, self-regulation is basically defined as the ability of controlling one's own behaviors or responses to external stimuli. In our study, difficulty to concentrate and focus in classes was one of the most quoted hesitations by students since they were easily distracted by social media, online movies, online games or the Internet in general, when connected to classes from anywhere other than a classroom with the physical presence of an instructor. Quite the reverse, and for good reason, students need to be more independent and autonomous in online learning environments with an ability to control, manage, plan and implement their learning actions (Ally, 2004), and take full responsibility for their learning and control their attention. This process is referred to as self-regulated learning (Zimmerman, 2008), and it allows for students to take full control and accountability for their learning. Students should be able to control their attention in order to self-regulate effectively. Attention control is one of the most cited reasons for negative opinions by participant students.

This is in parallel with their perceptions about the role of the instructor in virtual classes. Students assume an authoritarian control by the instructor in virtual classes, as they are used to experience in a face-to-face classroom, where the instructor is fully in charge of the learning environment. Without the presence of such authoritarian control, students tend to blame online technologies for their lack of focus and concentration, and failure to regulate their own learning. Qureshi, Ilyas, Yasmin, and Whitty (2012) also point out that students, who are externally regulated and used to being "spoon-fed" by the system, are likely to have a negative attitude and almost a frustration or dissatisfaction with online learning; and this generally leads to total rejection.

Likewise, Andersson and Grönlund (2009) emphasize that such students are uncomfortable when they are forced to abandon this traditional teaching style since they perceive the classroom as the most appropriate place for teaching and learning. In our study as well, statements of a considerable amount of students show a great degree of resistance since they have felt 'threatened' by online learning technologies which have impacted on their already accustomed to in-person classroom environment.

Is Mathematics Suitable for Online Delivery?

Our study connects this standpoint also with the importance of the subject matter taught online. Many students have considered the time and place flexibility of online classes as an 'insolence' to the nature of the course. According to them, "mathematics is too important to be taught online", and its teaching requires a 'serious' learning environment (which they consider to be a classroom) with the physical presence of the instructor. This may have taken its roots from well-established prejudices about relatively conventional open and distance education practices in Turkey that started due to an increasing demand for higher education in the 1980s, where open or distance education programs were considered 'inferior' to other 'formal' degree programs. Nevertheless, teaching mathematics online, or more generally at a distance, is already a controversial issue discussed by many researchers for decades. Some researchers show a rather skeptical stance regarding fully online mathematics courses (e.g. Bernard et al., 2004), and some describe mathematics as one of the most challenging and difficult disciplines to be delivered online (e.g. Engelbrecht & Harding, 2005; Glass & Sue, 2008; Lokken, 2011). Trenholm's dissertation (2013) on the adaptation of tertiary mathematics to the virtual medium also refers to meta-analytic findings, which put forward mathematics instruction as 'best suited to the classroom' (Bernard et al., 2004, p.400), and several other research studies about teaching mathematics online, student satisfaction (e.g. Summers, Waigandt, & Whittaker, 2005) and attrition (e.g. Mensch, 2010). As seen, current research does not reveal a clear picture of online mathematics instruction. Yet, design of proper digital tools with pedagogical potential, as well as a strong instructor presence and creation of the required educational context in view of learners' needs are emphasized as crucial factors for the successful use of digital technologies in mathematics education (Drijvers, 2012).

In connection with this, findings also point to a difficulty to use the language of mathematics for setting and receiving tasks and homework online, or using the real-time chatroom feature of the virtual classroom. It is clear that mathematical language (e.g. f of x is equal sqr(x^2-5) for f(x)=√(x^2-5)) has 'rigid syntax constraints... [which are]...difficult for students to learn' (Smith, Torres-Ayala, & Heindel, 2008, p.72); however, there are certain software or certain tools within word processing software for writing formulae and/or mathematical

symbols. Thus, since most of the students may lack these computer skills, extra priority should be given to basic computer skills and e-readiness of learners for online learning, either in the form of orientation sessions or structured basic ICT courses given in the freshman year to prepare and familiarize them with these technologies. Students have also linked this difficulty of taking notes in mathematical language to the fast pace of virtual classes, where it is not possible to have face-to-face discussions or recitation sessions with the instructor, as would occur in a physical classroom environment.

Interaction

Interaction is a significant factor in student satisfaction with online learning. Students desire to be in constant personal contact with their instructors, both in the classroom and through office hours. On-campus students have the opportunity to use office hours to personally meet their instructors, however a lack of personal interaction in virtual classes is still seen as a major drawback for them. Communicating merely through text messages or real-time chats does not feel like communication in real terms, and some students even consider these real-time chat practices in virtual classes as 'distracting' because of the volume of messaging, some out-of-context, that inhibit their communication with the instructor.

Barriers to Acceptance of Online Learning

We have considered students' concerns about learner-instructor interaction as a social barrier to online learning. Technical barriers are also imperative in terms of technology acceptance in education, which include having access to computers or certain applications, Internet access, Internet connection speed, smooth operation of learning management systems, and technical support. Accessibility advantage of online learning may also be considered as a barrier since students with no home computer or Internet access have to pay for Internet cafés unless institutions provide computer laboratories for such students. Barriers to acceptance of online learning include students' concerns about the timing of classes. This is an institutional barrier that should be handled with care by the relevant department when designing weekly course programs, since students have difficulty to follow their courses if their online courses are placed between two face-to-face courses or their face-to-face course starts immediately following an online course which they join from someplace other than the university campus.

Many students troubled by these personal, temporal and institutional barriers prefer a face-to-face learning environment for mathematics. Yet, there is a considerable number of students enthusiastic about the use of online learning technologies to support classroom activities. Hence, the idea of a hybrid course is very attractive for them where they can learn theoretical parts of a course in a physical classroom, with the presence of an instructor, supported with online recitation hours. The appealing impact of multimedia for illustrating abstract topics as well as practicality of using a smartboard for exercises and solving problems is quite obvious in students' reflections about online learning, particularly of those who are rather opinionated about online learning, yet changed their attitudes during the course of virtual classes. This brings us back to the clear need for orienting students and introducing the use of online technologies. A structured orientation of on-campus students about online courses, reinforced with introductory and helpful videos, is critical particularly to overcome preconceptions of students trapped within old habits of learning in a classroom in the physical presence of a lecturing instructor. Berge (2001) also very much supports the idea of "orientation" for novice online learners: "Instructors have a right to expect that participants will come to distance learning experiences prepared to study effectively at a distance…(such materials as)…a student handbook, a preliminary screening survey, or even a mini-course that would help ensure that learners acquire appropriate study and learning skills and understand their rights and responsibilities in a distance learning course" (pp.20-21). This parallels with learners' approach towards this experience from a specific perspective reflecting on prior learning, attitude change, active participation and presence. Learners with prior knowledge of the subject matter (i.e. retake students), or of online technologies in general, feel more comfortable with online classes, and adapt themselves better than others.

Conclusion

Affordances provided by digital technologies have changed the method of delivery particularly at higher education. Today, growing number of universities use online technologies to transform on-campus courses to fully online or blended courses. Such transformation requires a careful planning and involvement of all

stakeholders in the process in order to be successful and efficient. Yet, an important voice seems to be missing in the process: learners' voice. Lagrange (2014) lists specific challenges related to the students regarding low level of pre-knowledge, motivation and achievement as well as challenges also related to 'constraints and affordances of those digital technologies that are especially attached to mathematical activity'. These are the challenges revealed by this very study. Online learning should be considered not merely from a technological aspect, but also from social and pedagogical aspects. As Çağıltay (2001) pointed out, there will be severe consequences if it is only considered as a natural outcome of technological developments, and not take in human and instructional perspectives in a scientific manner such as learner-learner and learner-instructor interaction, active and engaging learning techniques, immediate and rich feedback, pacing, motivation and learner differences.

Future Research

Further research is necessary to reflect students' voice in planning, creation and implementation of online or blended learning environments as main stakeholders of the learning process. Their perspectives, anxieties and perceived barriers may serve as a useful tool to design more efficient learning environments. Besides, similar research should be conducted at other universities both on teaching mathematics using online technologies and for other disciplines.

References

Allen, G. D. (2001). Online Calculus: The Course and Survey Results. *Computers in the Schools 17*(1/2), 17-30.

Ally, M. (2004). Foundations of educational theory for online learning. In T. Anderson & F. Elloumi (Eds.), *Theory and practice of online learning* (pp.3-33). Athabasca: Athabasca University.

Akdemir, O. (2008). Teaching math online: current practices in Turkey. In J. Luca & E. Weippl (Eds.), *Proceedings of World Conference on Educational Media and Technology 2008* (pp. 2804-2809). Association for the Advancement of Computing in Education (AACE).

Anderson, T. (2004). Teaching in an online learning context. In T. Anderson & F. Elloumi (Eds.), *Theory and practice of online learning* (pp.273-294). Athabasca: Athabasca University.

Andersson, A., & Grönlund, Å. (2009). A conceptual framework for e-learning in developing countries: A critical review of research challenges. *The Electronic Journal of Information System in Developing Countries, 38*(8), 1-16.

Arinto, P. B. (2013). A framework for developing competencies in open and distance learning. *International Review of Research in Open and Distance Learning, 14*(1), 1-11.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice- Hall, Inc.

Berge, Z. (ed.) (2001). *Sustaining distance training*. San Francisco: Jossey-Bass.

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Huang, B. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379-439.

Blair, R., Kirkman, E.E., & Maxwell, J.W. (2013). *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2010 CBMS Survey*. USA: American Mathematical Society.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: a systematic review. *The Internet and Higher Education, 27*, 1-13. doi:10.1016/j.iheduc.2015.04.007

Cerri, C. & Bonomi Barufi, M. C. (2003). Differential and integral calculus III through WebCT: analysis of results. *International Journal of Mathematical Education in Science & Technology, 34*(3), 335-341.

Cole, R. A. (2000). *Issues in Web-based pedagogy: A critical primer*. Westport, CT: Greenwood Press.

Creswell, J. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson Merrill Prentice Hall, Upper Saddle River, NJ

Çağıltay, K. (2001). *Uzaktan eğitim: Başarıya giden yol teknolojide mi yoksa pedagojide mi?* [Road to success in distance education: Is it technology or pedagogy?]. Retrieved from http://ocw.metu.edu.tr/file.php/118/Week10/Cagiltay.pdf

Drijvers, P. (2012). Digital technology in mathematics education: Why it works (or doesn't). In S. J. Cho (Ed.), *Proceedings of the 12th International Congress on Mathematics Education* (pp. 485-501). Seoul, Korea.

Engelbrecht, J., & Harding, A. (2005). Teaching undergraduate mathematics on the internet: Part II. *Educational Studies in Mathematics, 58*(2), 253-276.

Freudenthal, H. (1991). *Revisiting Mathematics Education: China Lectures*. Dordrecht, The Netherlands: Kluwer.

Glass, J., & Sue, V. (2008). Student preferences, satisfaction, and perceived learning in an online mathematics class. *MERLOT Journal of Online Learning and Teaching, 4*(3), 325-338.

Holmberg, B. (1995). *Theory and practice of distance education*. London: Routledge.

Kearsley, G. (2000). *Online education: Learning and teaching in cyberspace*. Belmont, CA: Wadsworth.

Keegan, D. (1996). *Foundations of distance education*, (3rd edition). London: Routledge.

Kinnari-Korpela, H. (2015). Using short video lectures to enhance mathematics learning – Experiences on differential and integral calculus course for engineering students. *Informatics in Education, 14*(1), 67–81. doi: http://dx.doi.org/10.15388/infedu.2015.05.

Kirkman, E., Lutzer, D., Maxwell, J.W., & Rodi, S.B. (2007). *Statistical abstract of undergraduate programs in the mathematical sciences in the United States: Fall 2005 CBMS Survey.* Washington DC: Conference Board of Mathematical Sciences.

Koper, R. (2015). How do students want to learn in online distance education? Profiling student preferences. *The International Review of Research in Open and Distributed Learning, 16*(1), 307-329.

Lagrange, J. B. (2014) Teaching mathematics online: emergent technologies and methodologies, *Research in Mathematics Education, 16*(2), 208-212. doi: 10.1080/14794802.2014.918342

Lee, J. (2014). An exploratory study of effective online learning: assessing satisfaction levels of graduate students of mathematics education associated with human and design factors of an online course. *International Review of Research in Open and Distance Learning, 15*(1), 111-132.

Lewis, D., & Allen, B. (2005). *Virtual learning communities: A guide to practitioners*. Maidenhead: Open University Press.

Lokken, F. (2011). *Trends in e-learning: Tracking the impact of e-learning at community colleges: 2010 distance education survey results*. Washington, D.C.: Instructional Technology Council.

Lynch, R., & Dembo, M. (2004). The relationship between self-regulation and online learning in a blended learning context. *International Review of Research in Open and Distance Learning, 5*(2), 1-16.

Majid, M. A., Huneiti, Z. A., Al-Naafa, M. A., & Balachandran, W. (2013). A study of the effects of using MATLAB as a pedagogical tool for engineering mathematics students. *International Journal of Online Engineering, 9*(2), 27-35.

Marshall, C., & Rossman, G. B. (1999). *Designing Qualitative Research* (3rd Ed.). Thousand Oaks: Sage Publications.

McConnell, D. (2006). *e-Learning groups and communities*. Maidenhead: Open University Press

Mensch, S. (2010). Issues in offering numeric based courses in an online environment. *Journal of Instructional Pedagogies, 3*(2), 1-7.

Naidu, S. (2013). Instructional design models for optimal learning. In Moore, M.G. (Ed.), *The Handbook of Distance Education*, (3rd ed., pp. 268-281). New York, Routledge

Peters, O. (1998). *Learning and teaching in distance education: analyses and interpretations from an international perspective*. London: Kogan Page.

Qureshi, A.I., Ilyas, K., Yasmin, R., & Whitty, M. (2012). Challenges of implementing e-learning in a Pakistani university. *Knowledge Management & E*-Learning (KM&EL), 4(3), 310-324.

Romero, M., & Usart, M. (2014). The temporal perspective in higher education learners: comparisons between online and onsite learning. *European Journal of Open, Distance and e-Learning, 17*(1), 190-209.

Simonson, M., Smaldino, S., & Zvacek, S. (2015). *Teaching and learning at a distance: Foundations of distance education* (6th ed.) Charlotte, NC: IAP.

Smith, G. G., Torres-Ayala, A. T., & Heindel, A. J. (2008). Disciplinary differences in e-Learning & Instructional design. *Journal of Distance Education, 22*(3), 63-88.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage.

Summers, J. J., Waigandt, A., & Whittaker, T.A. (2005). A comparison of student achievement and satisfaction in an online versus a traditional face-to-face statistics class. *Innovative Higher Education, 29*(3), 233-250.

Trenholm, S. (2013). Adaptation of tertiary mathematics instruction to the virtual medium: approaches to assessment practice. Unpublished doctoral dissertation. Loughborough University, UK. Retrieved from https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/12561/3/Thesis-2013-Trenholm.pdf

Wang, C., Shannon, D., & Ross, M. (2013). Students' characteristics, self-regulated learning, technology, self-efficacy, and course outcomes in online learning. *Distance Education, 34*(3), 302-323.

Yin, R. K. (2009). *Case study research: Design and methods* (4th Ed.). Thousand Oaks, CA: Sage

Young, C. Y., Georgiopoulos, M., Hagen, S. C., Geiger, C. L., Dagley-Falls, M. A., Islas, A. L., Ramsey, P. J., Lancey, P. M., Straney, R. A., Forde, D. S. & Bradbury, E. E. (2011). Improving student learning in calculus through applications. *International Journal of Mathematical Education in Science and Technology*, *42*(5), 591-604. doi: 10.1080/0020739X.2010.550944

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166-183. doi: 10.3102/0002831207312909.

Zhang, Y., & Wildemuth, B.M. (2009). Qualitative analysis of content. In B. M. Wildemuth (Ed.), *Applications of social research methods to questions in information and library science* (pp.308-319). Westport, CT: Libraries Unlimited.

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