



MAPPING STUDY OF MOOC PROVIDERS: THE CURRENT STATE OF COMPUTER SCIENCE EDUCATION AND PLATFORM TECHNICAL CAPABILITIES

Lappeenranta-Lahti University of Technology LUT

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Examiner: Ari Happonen, D.Sc. (Tech.)

ABSTRACT

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Mapping study of MOOC providers: The current state of computer science education and platform technical capabilities

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42 pages, 11 figures, 4 tables and 0 appendices

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This thesis deals with massive open online courses, more commonly known as MOOCs. These platforms have become very popular in the coming years due to the spread of digitalization and the remote working caused by the pandemic. The work examines how the teaching of information technology is displayed on these platforms, as well as what functionalities the platforms offer. The courses of different platforms are analyzed based on their themes and what functionalities they offer to users. The findings are compiled and compared to previous research on MOOC courses and platforms.

It was identified that education of computer science-related courses was very similar with the largest MOOC providers. However, smaller MOOC providers had more considerable variance depending on what subjects the provider specializes in. Entry-level computer science courses are taught widely, but specialized fields and subjects inside the IT industry are more uncommon to find on smaller platforms.

The research also highlighted the stark difference in basic technical capabilities between the platforms. Larger platforms offer a wide selection of tools and features to support the learning experience, whereas smaller platforms lack most features. This primarily impacts the type of learners the platform caters to and the type of courses the course designers can implement.

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Tämä tutkielma käsittelee massiivisia avoimia verkkokursseja eli MOOCeja. Kyseiset alustat ovat saavuttaneet suurta suosiota lähivuosina digitalisaation yleistyessä sekä pandemian aiheuttaman etätyöskentelyn vuoksi. Työssä tarkastellaan, kuinka tietotekniikan opetus näkyy kyseisillä alustoilla, sekä mitä toiminnallisuuksia alustat tarjoavat. Eri alustojen kurseja analysoidaan niiden teemojen perusteella sekä mitä toiminnallisuuksia ne tarjoavat käyttäjille. Löydökset kootaan yhteen ja niitä verrataan aiempaan tutkimukseen MOOC-kursseista ja -alustoista.

Tutkimuksessa tunnistettiin, että suurimpien MOOC tarjoajien tietotekniikan kurssitarjonta oli hyvin samanlainen. Pienemmät MOOC-alustat sisälsivät enemmän vaihtelua kurssien sisällön ja määrän osalta, riippuen niiden erikoistumisalasta. Aloittelija-tason tietotekniikan kurseja opetettiin laajalti, mutta tietotekniikan eri erikoistumisaloihin ja uusiin teknologioihin erikoistuvia kurseja oli haastavampaa löytää pienemmiltä alustoilta.

Tutkimus myös osoitti selvän eron alustojen teknillisten toiminnallisuuden ja kyvykkyysien välillä. Suuret alustat tarjoavat laajan valikoiman työkaluja ja toiminnallisuksia oppimiskokemusten tukemiseen, jossa vuorostaan puuttuvat pienemmiltä alustoilta. Tämä vaikuttaa paitsi kurssien suunnitteluun, mutta myös kurssien suorittamiseen käyttökokemuksen perusteella.

SYMBOLS AND ABBREVIATIONS

MOOC	Massive Online Open Course
IoT	Internet of Things
S-O-R	Stimulus-organism-response
IT	Information technology
MIT	Massachusetts Institute of Technology
AWS	Amazon web services
USD	United states dollar
US	United state
ARRM	Annual recurring revenue milestone
AI	Artificial intelligence
UK	United Kingdom
ECTS	European credit transfer and accumulation system
ML	Machine learning
UI	User interface
TMC	Test My Code
UX	User experience

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1 Introduction

Digitalization is one of the largest sources of disruption in modern society and it is affecting every work task and business process that is susceptible to be digitized using information technology (Seufert & Meier, 2016). Digitalization has seen to impact the aerospace industry through Internet of Things (IoT) and Digital twins (Carou, 2021), the procurement process and tools (Heiskanen, 2018), and the retail industry (Hagberg et al., 2016). An industry heavily impacted by the effects of digitalization is education, which has seen the rise of alternative learning paths compared to more traditional learning methods and institutions (Seufert & Meier, 2016).

Online learning or e-learning is remote education using the internet. The students are provided necessary materials, and mandatory assignments are completed online. (Moore et al., 2010) The adoption of information technology is characterized to improve the quality and efficiency of learning (De Oliveira Fassbinder et al., 2015). This points to the increase of online learning in the future. The same is proposed by Sultan (2019), who sees traditional classroom education disrupted by massive online open courses (MOOCs). MOOCs are one of the most popular mediums of online learning (Staubitz et al., 2015). As the name suggests, MOOCs are courses, which are open to all participants, without limitations to classroom sizes or accessibility (De Oliveira Fassbinder et al., 2015). MOOC courses are free of charge to access but might be subject to a fee to receive a certification of completion or student credits (Czerniewicz et al., 2015). MOOC courses can be organized using continuous enrollment or a scheduled course, where participants can interact with the lecturer and other students.

MOOC courses are organized and hosted on a multitude of platforms, of which some of the largest are Coursera, edX, Canvas, and FutureLearn (Czerniewicz et al., 2015). Other popular MOOC providers are Udemy, Udacity, Khan Academy, Open Education Europa, and The Open University (EduTechReviews, 2017). In Finland, MOOC courses are provided by the University of Helsinki and the University of Eastern Finland (Rautio, 2019).

Most MOOC providers offer introductory courses in programming, and MOOC courses can introduce programming to a larger audience (Staubitz et al., 2015). In addition, MOOCs provide information and knowledge to various groups internationally, which historically have not had access to before (Chin & Jacobsson, 2016). A source of synergy has been identified in organizing MOOC courses of computer science and information technology, which promote independent work. On many MOOC platforms, computer science courses have been in the most popular categories of subjects. For example, the MOOC provider edX has over 3500 courses, of which 691 are computer science-related courses (edX, 2021).

1.1 Goals and methods

The thesis aims to investigate various MOOC providers and platforms from the point of view of computer science education and technical capabilities. The goal of the thesis is for research to be utilized as a reference in designing online courses in different educational institutions and companies that provide online learning services. The research can also develop pre-existing MOOC platforms and -courses by including features from other platforms.

The main research question is: What is the current state of MOOCs from the point of view of computer science education? The aim is to examine selected MOOC providers' selection of courses and research if different platforms have differences in content and how computer science education is portrayed on the platform. In addition, the research question highlights the current computer science-related trends on MOOC platforms.

The other research question is: What type of technical capabilities do the leading MOOC providers have? The purpose is to define the differences in organizing MOOC courses on the different platforms. The research question aims to emphasize what one designing a MOOC course must take into consideration beforehand.

To limit the scope of the thesis, the research aims to familiarize the content of MOOC courses superficially. The research does not focus on the content of the course or its validity but instead aims to discuss the subject on a general level and the technology that it relies upon. Furthermore, the research focuses on MOOC courses that are only available in 2021 or the latest course in multiple implementations. The limitation is the rapid technical development of the courses and platforms, where the latest course implementation can be assumed to utilize the most advanced technology. The limitation is also in place to limit the total amount of research needed and the limited availability of the courses.

The research does not aim to design or implement a MOOC course, nor does the research aim to be a specific guide in designing MOOC courses instead of a current snapshot of the MOOC platforms. Instead, the research is aimed at technical features that are possible to research with the selected research method and thus exclude many back-end tools and features.

1.2 Thesis structure

The thesis consists of five chapters. The introduction chapter aims to familiarize the reader with MOOCs and the research questions the thesis aims to answer. The second chapter describes the related research around MOOCs. This provides the reader with additional information on the topic of MOOC courses and platforms. Finally, possible future research is identified based on the findings of related research.

The third chapter elaborates on how the researcher conducted the research. It justifies using the selected research methods, analysis, categorization, and selection of MOOC platforms. The selected MOOC platforms are introduced and detailed to provide context. The fourth chapter elaborates the findings of the research in detail. The research results are visualized and discussed to answer the initial research questions set in the first chapter. Finally, the last chapter concludes the thesis by summarizing the essential findings and discussing the future of the topic.

2 Related research

The following paragraphs look at the topic from the perspective of previous research and literature. The literature review consists of four main parts. First, the theme of MOOC courses is investigated through the completion and drop out of courses. This is followed by a study of the scientific literature from further research on MOOC features. The third subsection consists of prior research on the importance of collaboration to MOOC courses and platforms. Finally, MOOC courses are processed from a transition point of view.

2.1 MOOC completion and dropout

Nearly 90% of all learners on MOOC courses never finish the course (Gomez Zermeño & Aleman de la Garza, 2016). Factors that contribute to this include course structure, lack of guidance, quality of materials, and limitations of the MOOC platform (Goopio & Cheung, 2021). However, the motivation of the learner leads to higher completion of the MOOC course. Most learners are more likely to complete a course if they are motivated to complete it and do not have structural difficulties that lead to dropout. (Luik & Lepp, 2021).

Albelbisi et al. (2021) demonstrated that the success of MOOC courses is directly related to the satisfaction of the course. This is attributed to the learners' self-regulated learning and the system quality of the MOOC platform. On the other hand, the learners' low skill in managing their learning leads more often to course dropouts. System quality attributes that contributed to the overall rise in satisfaction of the MOOC course were ease-of-use and necessary features and functions. The user interface and -experience also contribute to the users satisfaction of the platform (Korableva et al., 2019). Lu, Bin and Yaobin (2019) found that satisfaction is a key diver in user retention on MOOC courses. Especially the perceived usefulness and interest had a large impact on the satisfaction of the user.

2.2 MOOC features

Xing (2019) demonstrated in his research of MOOC course features that a combination of many assignments, peer reviews, different submission types, and grading types result in the lowest dropout rate and highest average grade. On the other hand, a high number of quizzes but a low number of assignments, discussion forums, and peer reviews lead to low grades, long completion times, and dropouts. This indicates the importance of varying assignments and student collaboration in MOOCs promote learning.

Chauhan and Goel (2016) researched the different types of quizzes on MOOC platforms. As a result, they identified a comprehensive checklist of quiz-related features applied to other MOOC platforms. From the research, two main types of quizzes were identified: independent and embedded quizzes. Chauhan and Goel (2020) also researched various platforms' other social networking and collaboration features. There was a significant difference in the types of social networking features the platforms offered. For example, NovoEd and Moodle lead with 85% of all identified features in in-course network features, whereas edX has the least at 14%. Based on the research, the best proprietary platforms for networking are edX, Coursera, Udacity, and NovoEd.

Comparing two large MOOC providers, Coursera's and edX's video and viewing related features produce exciting results in the importance of video-related features. For example, according to surveyed students, Coursera's captions block information, whereas edX's do not. EdX also scored higher in video quality and ease of use than Coursera's video player. In addition, students found embedded quizzes in videos necessary for their learning. Overall, students preferred edX over Coursera when surveying an overall preference indicating the video-related features to contribute to the MOOC platform's user satisfaction. (Mamgain, Sharma & Goyal 2014).

2.3 Collaboration on MOOCs

Applying the stimulus-organism-response (S-O-R) framework to investigate the importance of features to MOOC platforms provided insightful information on the topic. Introducing interactivity, social features, and rich media strongly increased the users' willingness to continue to use the MOOC platform. (Zhao, Wang & Sun 2020)

Research on collaboration features of MOOC platforms produced high compatibility of many basic collaboration features such as course certifications, discussion forums, and video-format content. In addition, by analyzing the MOOC platforms, researchers were able to identify measures to increase interactivity and collaboration on MOOC courses, resulting in higher user satisfaction. The measures include engaging learners, co-creating course content with students, and designing the course to support interaction between students and teachers at a larger scale. (Gamage, Fernando & Perera 2020).

2.4 Transitioning to MOOCs

Moving from traditional classroom-based courses to MOOC courses has its difficulties for teachers. However, it also has many benefits, such as teaching flexibility, scaling education to a large audience, and professional development. This comes with the drawbacks of designing the courses so that they offer the same level of education online. Also, difficulties include technical difficulties, time management, and cooperation between the lecturer, students, and other universities. (Tuononen, 2020)

Adopting MOOCs as a learning method has many flaws related to it. A total of eight different factors were identified that negatively affect the use and adoption of MOOCs by learners and teachers. These factors include understanding how to use MOOCs, student motivation, IT equipment, and MOOC course offerings. The survey of participants to MOOC courses highlighted that adoption is slowed mainly through external factors such as Wi-Fi coverage rather than internal factors like motivation. However, poor offering of courses was the

second-highest challenge contributing to not using MOOCs. (Zulkifli, Hamzah & Bashah 2020).

Viswanathan (2012), in their research of MOOCs, also found some issues related to teaching online courses. Some of the issues included lack of knowledge in the subject, time management, and poor Wi-Fi connectivity. Also, mobile applications in learning and other advanced software turned out to be challenging to take into use.

3 Research method

This chapter goes over how completing the thesis is being approached. The following sections cover the chosen tools and methods, information processing as well as preliminary tests. The purpose of the chapter is to clarify the planned starting baseline and research methods of the thesis.

3.1 Methods and tools

The procedures and tools utilized by the research are limited to a selected number of options. The most comprehensive method of analysis is to obtain access rights to MOOC platforms to create courses. This approach is disadvantageous in many aspects. For an encompassing result, the study would require access rights to multiple MOOC platforms. Obtaining access rights cannot be done without significant support from the university in procuring the required accesses. Even with the help of the faculty, the result is uncertain. Most of the MOOC providers have limited their selection of partner universities to a few exclusive partners. In addition, the process required to procure the access rights is a more long-lasting process than the timeframe allocated for the research.

The selected course of action is to analyze the MOOC courses and platforms from the openly available material and through studying the contents from the point of view of a user. MOOC courses are free and open as of their nature, which allows analyzing them simply and efficiently. In addition, the MOOC courses have the most necessary information located on the course page, which reveals the different tools and features the course utilizes. The MOOC platforms provide basic filtering, which expedites data gathering and analysis by focusing on the type of courses the research concentrates on. Although the data gathering phase can be expedited in many ways, the analysis of individual courses is an arduous and time-consuming task. There are no tools that could efficiently be applied to the research. Building a custom tool to accelerate the process is impractical due to the number of different MOOC

providers. The significant difference in the platforms constrains the data gathering to be done manually by the author of the thesis.

The features and functionalities are also being researched from other sources than the platform's user. Some platforms offer open documentation of the platform for designers and developers of the courses, which contain relevant information on the capabilities of the MOOC platforms. This information can be used to verify the research results or as a baseline of the platform's capabilities. Due to the uniqueness of many MOOC courses, the official documentation can be relied on to contain the most accurate and up-to-date functionalities that many courses might not apply.

3.2 Data gathering and MOOC Selection

Data collection was approached in an analytical and planned way. First, precise classifications and categories were set for data collection, how information is retrieved from the objects and studied. Then, the examined MOOC courses and providers were carefully selected. Finally, conditions were set for MOOC platforms, according to which the final selections of the MOOC platforms selected for comparison will be made. These conditions aim to filter out platforms that make it difficult to retrieve information and platforms that violate MOOC's design principles.

The selected conditions are:

- 1 Availability. The MOOC platform and the courses it contains must be available in Finland so that the employee can analyze the MOOC in question.
- 2 Language. The MOOC platform must be in Finnish or English so that the researcher can analyze the MOOC in question.
- 3 Origin. MOOC platform courses should be from a selected platform and not from other MOOC platforms. MOOC search engines are not included in the comparison.

- 4 Price. Access to the MOOC courses should be free. However, there may be a charge for redeeming a certificate of completion of a course. The selection has been made to allow the developer to analyze that MOOC.

From the conditions, a final selection of 8 MOOC providers were compared and analysed. The selected MOOC platforms are:

- 1 edX
- 2 Coursera
- 3 Udemy
- 4 Udacity
- 5 FutureLearn
- 6 Khan Academy
- 7 Iversity
- 8 Mooc.fi

The platforms vary in size, target audience, business model, and geographical location. This was done to provide a complete result and highlight the differences between the available MOOC platforms.

3.3 MOOC providers

The following section further introduces the eight selected MOOC providers and elaborates on the surface-level differences between them.

3.3.1 EdX

EdX is one of the leading MOOC providers in the world with over 35 million users and 110 million course enrollments (edX, 2021). Founded in 2012 by reputable universities

Massachusetts Institute of Technology (MIT) and Harvard University, edX provides a wide range of degree-level courses and programs worldwide. Later, accompanied by Stanford University, edX has attracted tens of partner universities, mainly from North America, Europe, and Asia. Alongside more traditional learning institutions, edX partners with large technology companies such as Google, Amazon Web Services (AWS), and Microsoft. (edX, 2021).

Courses are created by a vast network of partners. With 3500+ courses, edX has a compelling selection of courses offered to university students, graduates, and professionals looking to expand their knowledge or obtain a certification. EdX offers courses on various types of topics. The MicroBachelors and MicroMasters programs are more extensive collections of courses designed to imitate a pre-existing degree but at a smaller scale. The programs, unlike individual courses, are paid at the start of the program and, depending on the program, might count towards the more extensive at-university program. (edX, 2021)

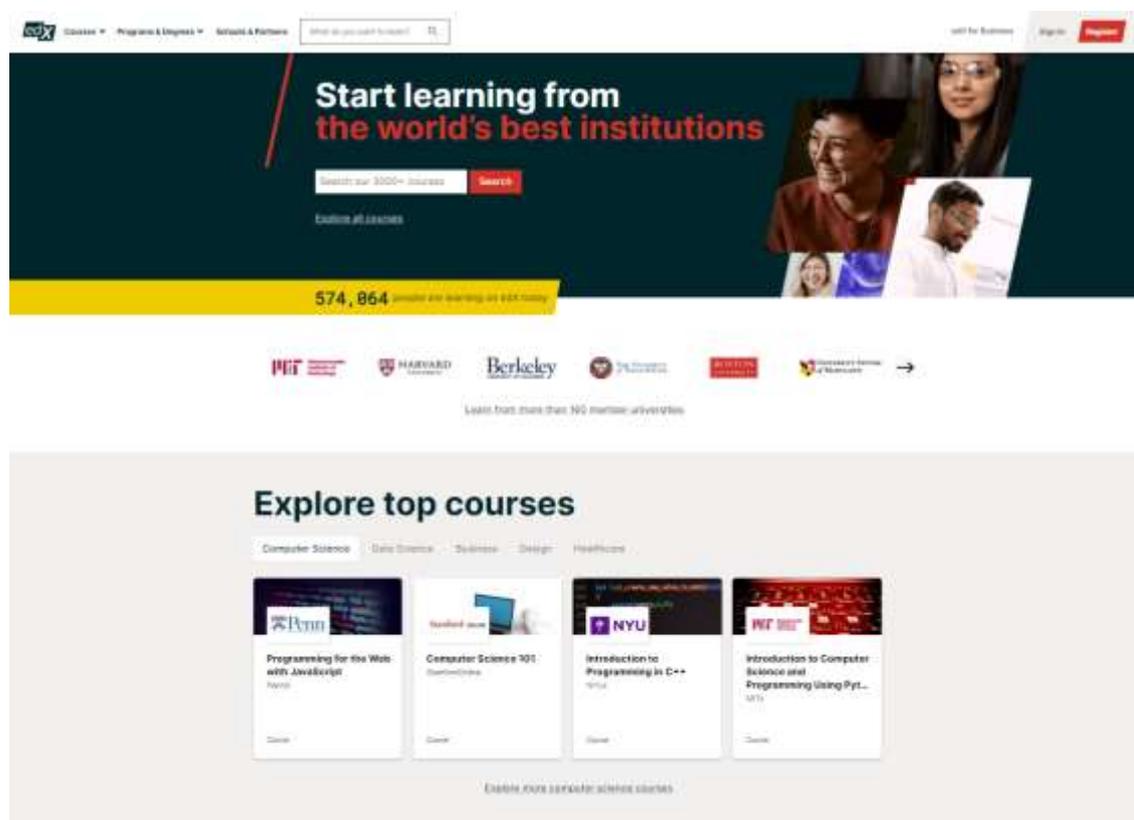


Figure 1. edX Frontpage

3.3.2 Coursera

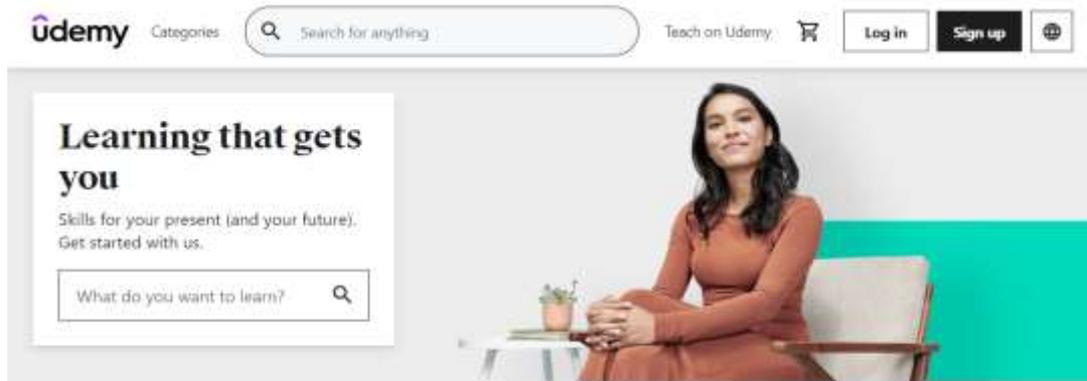
Coursera is a publicly listed MOOC provider based in the United States. Coursera, much like edX, was founded in 2012 by university professors from Stanford University. However, unlike edX, Coursera is a for-profit company with a revenue of nearly 300 million USD and 82 million worldwide users. In addition to courses, Coursera offers a wide range of professional certificates and degrees for its users. Courses are developed and taught by over 200 partners, including universities worldwide and global enterprises such as IBM, Facebook, and Google. With more than 4000 courses, Coursera is one of the largest MOOC providers globally. Courses generally are free to access, but receiving a certification of completion is subject to a charge of 41-66€ per course. Alternatively, Coursera provides a paid subscription service of 49€ per month for unlimited access to most of its courses. Coursera offers several different courses with topics that vary from Health to Data Science and Personal Development. (Coursera, 2021)

The image shows the Coursera frontpage. At the top, there is a navigation bar with the Coursera logo, a search bar with the placeholder text "What do you want to learn?", and links for "For Enterprise", "For Students", "Log in", and "Join for Free". The main content area features the headline "Learn Without Limits" in large, bold, black text. Below the headline is a sub-headline: "Build skills with courses, certificates, and degrees online from world-class universities and companies." There are two buttons: a blue "Join for Free" button and a white "Try Coursera for Business" button. To the right of the text is a circular image of two women, one Black and one white, looking at a tablet together. Below this is a section titled "We collaborate with 200+ leading universities and companies" with logos for ILLINOIS, Duke, Google, M (MIT), IBM, Imperial College London, Stanford, and Penn (University of Pennsylvania).

Figure 2. Coursera Frontpage

3.3.3 Udemy

Founded in 2010, Udemy is the world's largest MOOC provider, with over 155000 courses and 40 million users. In addition, the for-profit company is one of the most global MOOC providers, with courses available in up to 65 different languages. Unlike other platforms, Udemy has opened its platform for individual creators instead of a selected group of academic and professional partners. This and their global presence have helped Udemy scale its selection of courses to such a high number compared to competitors. With over 7000 corporate customers, Udemy has raised its annual recurring revenue milestone (ARRM) to over \$100 million. Udemy, unlike edX and Coursera, has a large selection of courses starting from \$10 and going up to hundreds of dollars. As most of the partners are individuals, Udemy does not offer any degree programs for users. (Udemy, 2021a; Udemy, 2021b)



The screenshot shows the Udemy homepage. At the top, there is a navigation bar with the Udemy logo, a search bar with the placeholder text "Search for anything", and links for "Teach on Udemy", "Log in", and "Sign up". Below the navigation bar is a large banner featuring a woman sitting in a chair. The banner text reads "Learning that gets you" followed by "Skills for your present (and your future). Get started with us." and a search input field with the placeholder "What do you want to learn?". Below the banner, there is a section titled "A broad selection of courses" with the text "Choose from 155,000 online video courses with new additions published every month". A horizontal list of course categories includes Python, Excel, Web Development, JavaScript, Data Science, AWS Certification, and Drawing. Below this list is a promotional box for Python titled "Expand your career opportunities with Python", which includes a paragraph of text and an "Explore Python" button.

Figure 3. Udemy Frontpage

3.3.4 Udacity

Udacity, much like Coursera, is a for-profit US-based company offering free online education. Udacity partners with leading technology companies and universities to better educate the workforce for future challenges. The company has seen over 100000 students graduate and 100 enterprises as customers. The education offering consists of free courses and programs, which are also referred to as nanodegrees. The services are offered to individuals, companies, and governmental agencies to promote professional development. Courses are co-designed with tech companies and industry experts. Unlike many other MOOC providers, Udacity has not completely outsourced the development of courses to external parties but actively creates with or without their 200+ partners. (Udacity, 2021)

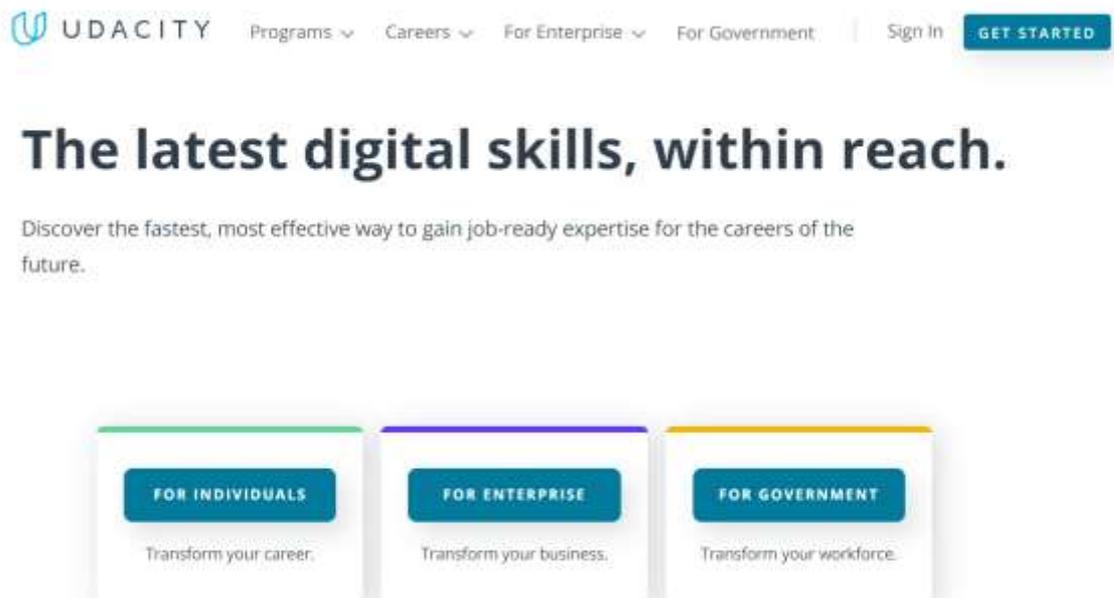


Figure 4. Udacity Frontpage

3.3.5 Khan Academy

Salman Khan founded Khan Academy in 2005 to offer world-class education to everyone. The company is a non-profit company that creates learning material for learners of all ages. However, most MOOC courses are for children and youth from first grade to high school and college. The MOOC courses are highly concentrated around the video format but offer other materials, exercises, and gamification to enhance the learning experience further. Like Udemy, Khan Academy has a large global focus, with MOOC courses are translated to 36 different languages and the website up to 50 languages. This has gained Khan Academy over 90 million users as of the end of 2019. (Khan Academy, 2021)



Figure 5. Khan Academy Frontpage

3.3.6 FutureLearn

FutureLearn is a UK-based learning platform that offers a wide range of courses from different partners. Founded in 2013 and co-owned by The Open University, FutureLearn aims to provide education worldwide. The types of courses provided by FutureLearn are individual courses, online degrees, accreditation programs, and specialized courses bundles called ExpertTracks. The courses are brought by a collection of international partners composed of Universities, Companies, Associations, and Governmental Agencies. FutureLearn has an extensive library of over 1900 courses, which have been studied over 35 million times. (FutureLearn, 2021)

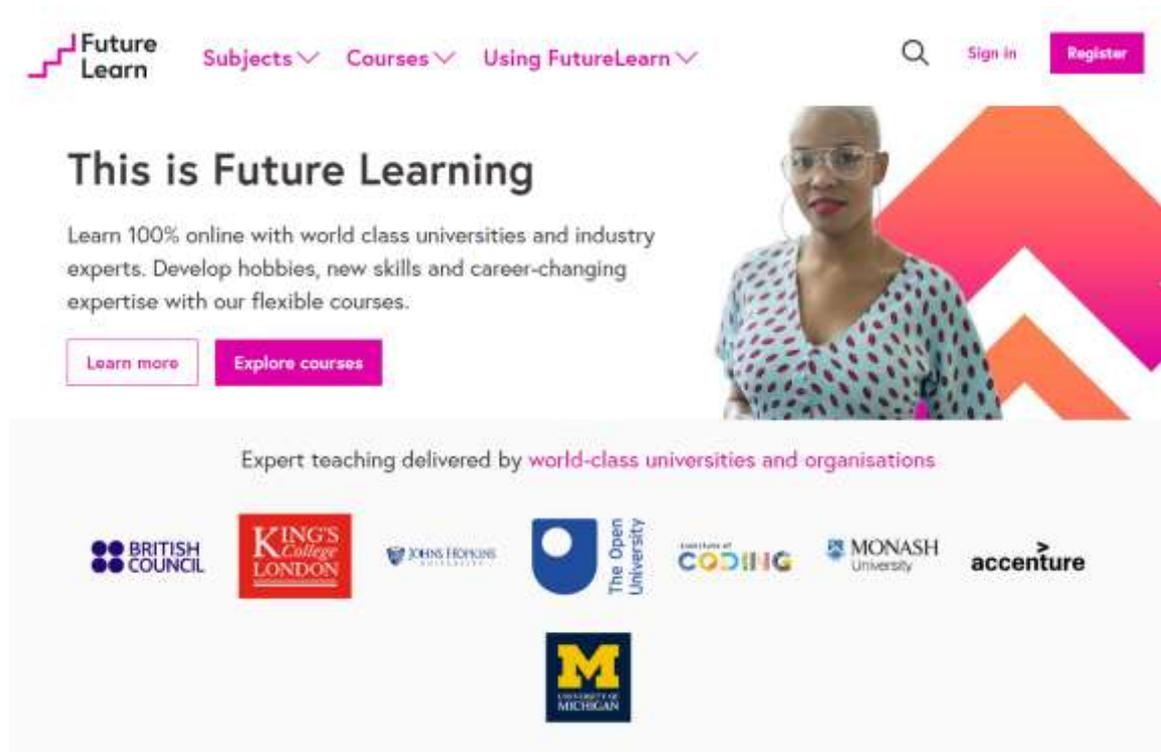


Figure 6. FutureLearn Frontpage

3.3.7 Iversity

Iversity was founded as a start-up in 2013. The founder Hannes Klöpfer established the platform to provide a fresh digital experience to disrupt the German educational environment. Iversity partners with over 100 partners such as the Graz University of Technology,

Maastricht School of Management, and KPMG. Publisher Springer Nature acquired Iversity in 2017. (Iversity, 2021; Springer Nature 2017)

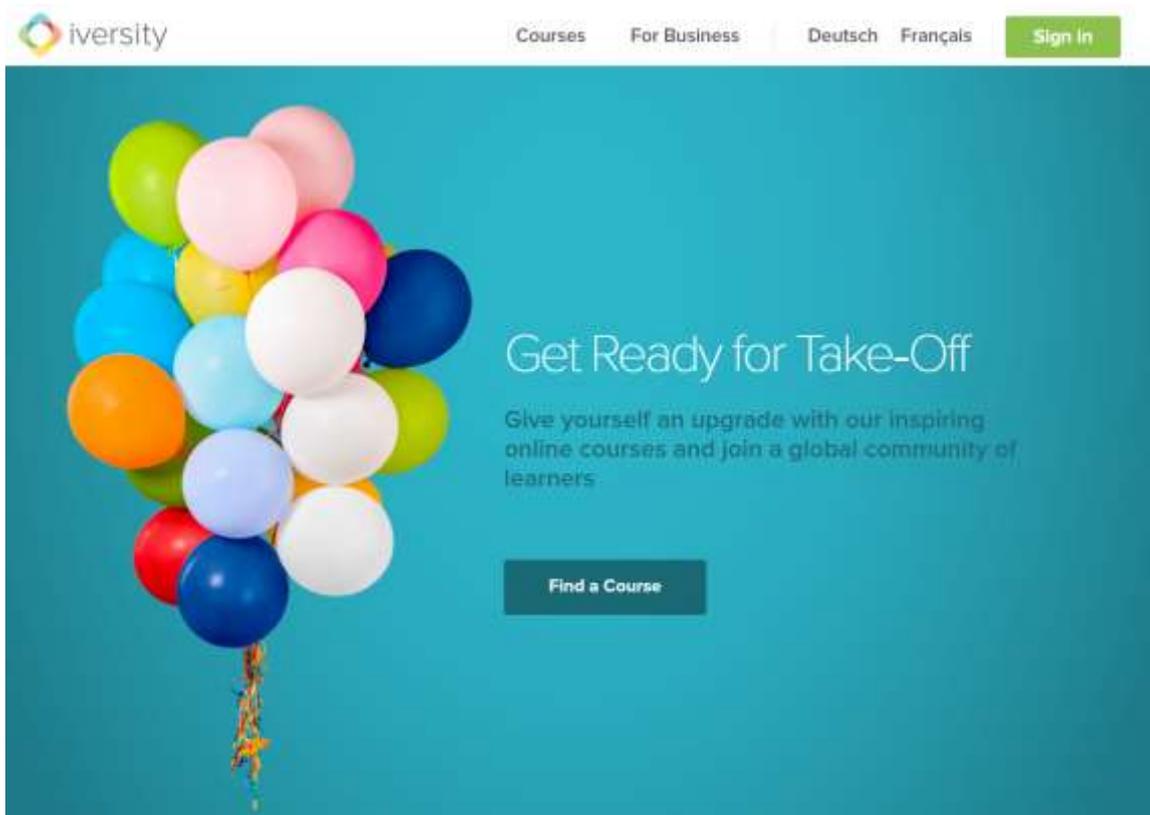


Figure 7. Iversity Frontpage

3.3.8 Mooc.fi

Mooc.fi is the most well-known Finnish MOOC provider. They were founded in 2011 by the computer science department of the University of Helsinki in the beginning as a course that promotes learning by doing. The first MOOC course was published in 2012 and attracted over 400 students, passing the expectations by over tenfold. The platform expanded courses to other computer science-related courses and partnered with Finnish IT companies such as Reaktor and F-Secure. The Elements of AI MOOC course co-designed with Reaktor has seen over 700000 users from 170 countries worldwide. The course has been translated to every European language, further expanding the global presence of the MOOC course and

platform. The platform offers 22 computer science-related courses, which are primarily free and offer certifications and ECTS to Finnish students. (mooc.fi, 2021a; Elements of AI, 2021; mooc.fi, 2021b)



Figure 8. Mooc.fi Frontpage

3.4 Result categorization and analysis

The analysis of the data utilized predefined categories with which the analysis can be performed quickly and accurately. The education of computer science was categorized by utilizing critical technologies from the IT industry. These technologies were identified using yearly published technology trend reports from respected actors in the industry. These selected technologies are included 2021 reports by Accenture, Deloitte, and Gartner. The themes and trends varied between the three, but all trends consisted of underlying technologies or themes. Deloitte (2020) identified as one of their technology trends as Zero trust, which is not a teachable subject on MOOC platforms, but instead a collection of cybersecurity practices. Similarly, Accenture (2021) defined “I, technologist” as a technology trend,

which utilizes automation as a key technology. From these trends a total of nine different technology categories was identified including: Architecture, Artificial intelligence, Cybersecurity, Cloud computing, Blockchain, Data science & analytics, Software business, and

User experience and interfaces. In addition, two categories were added, which were not part of the technology trends reports. These are programming and computer science, and they are added to cover introductory-level courses, whereas other themes are more specialization focused.



Figure 9. Top strategic trends 2021 (Gartner, 2020)

The results of the analysis are presented visually in the form of cross-tabulation. The tables aim to provide a holistic view of the results of the research. The tables are colored to properly indicate the differences on each MOOC platform. These are used to explain and further elaborate the conclusions of the analysis.

4 Results

The chapter introduces the results of the research. Then, it elaborates the findings to create an overview of the current state of MOOC platforms and courses. The first section introduces the IT-related courses on the MOOC platforms and elaborates the differences between the platforms. The courses are inspected from the point of view of the general themes, the number of courses, most popular courses, and platform-specific differences. The second subsection compares the technical capabilities of the MOOC platforms. The last subsection discusses and compares the results of the analysis to previous research

4.1 Analysis of computer science education

The following chapter further elaborates on the findings on the differences of computer science education on the MOOC platforms.

4.1.1 Quantity of computer science courses

The research demonstrated well the differences in how computer science and IT are taught on different MOOC platforms. The range of computer science and IT-related courses varied between 7 and over 50000 (Table 1). This range allows for a considerable variation in the general themes that are taught on the platforms. This can later evidently be seen when comparing the computer science themes inside the MOOC platform. The MOOC providers can be roughly divided into three types of providers.

Large MOOC platforms. The prominent players in the MOOC provider space consist of edX, Coursera, and Udemy. These platforms all have over 1000 courses, but they are not specialized in any theme but instead have a more general approach. The allocation of IT-related

courses on the platform varies from 26-33%, a substantial portion but does not indicate specialization. In most cases, the most popular category is business studies.

IT-specialized MOOC platforms. As the name suggests, these MOOC providers are specialized in providing IT-related courses on the platform. The size of the platforms varies, but the percentage of IT courses is very high. The range of the detected IT-related courses on the platform varies from 94-100%. This category consists of Udacity and Mooc.fi, which both specialize in programming.

IT-limited MOOC platforms. This category of MOOC providers consists of FutureLearn, Khan Academy, and Iversity. In common, these providers have that they provide MOOC courses but to a limited scope. The number of courses varies from thousands to tens of courses, but the portion of IT-related courses is between 5 and 11 percent. Of the three groups, this is the least number of courses, and the most popular category on these courses varies but is not IT-related.

	edX	Coursera	Udemy	Udacity	FutureLearn	Khan Academy	Iversity	Mooc.fi
Total number of MOOC courses	3514	4313	155000	193	1937	131	77	22
Total number of IT courses	1042	1238	50440	179	215	7	7	22
Percentage of IT courses	26 %	29 %	33 %	94 %	11 %	5 %	9 %	100 %
Most popular category	Business & Management	Business	IT & Software	Programming & Development	Business	Math	Interdisciplinary	Programming

Table 1: Number of Computer science courses on MOOC platforms

4.1.2 Analysis of computer science themes

Utilizing the categorization of IT-related course themes produces a result, as seen in Table 2. The differences in the MOOC providers come very clear. Half of the MOOC providers scored a complete 11/11 different IT themes in the comparison.

The large MOOC providers performed the best in the comparison. The scale of their library of courses provided the best coverage of IT industry trends. The comparison indicates a correlation between the number of courses a MOOC platform has, and the number of different themes present. However, the platforms approach diversifying the course library differently. EdX and Coursera depend on their partner network of Ivy-league universities and Silicon Valley-based tech companies to bring the latest trends in IT to the platform. These organizations are in many ways regarded as the forerunners in innovation, and the MOOC courses amplify this notion. Udemy, much like edX and Coursera, relies on the partner network to bring the latest innovation and trends onto the platform. This is achieved through the strength in numbers. The partners on Udemy are not as well regarded as on edX and Coursera, but the vastness of individual educators can cover most specializations and trends.

The IT specialized MOOC platforms are divided when comparing the coverage of IT themes. Mooc.fi had an impressive 100% specialization in IT-related courses, but it has only 5/11 of the IT trends represented on its platform. Udacity, however, has performed excellently and is equally as good as the larger MOOC providers. The difference between the two MOOC providers is the size of their selection of courses. Udacity is roughly ten times as large as mooc.fi, which is the main contributor to the difference. Another factor is the partners that both MOOC providers have built the library of courses onto the platform. Of the two, Udacity has more but also more well-regarded industry leaders assisting in creating the courses.

The IT-limited MOOC platforms performed the worst in the comparison. This was, however, to be expected as the total number of available courses was the lowest. From the category, FutureLearn performed the best with 8/11 themes present. This was due to the overwhelmingly higher count of available MOOC courses. Iversity performed the worst in the comparison, with only 2/11 themes present.

	edX	Coursera	Udemy	Udacity	FutureLearn	Khan Academy	Iversity	Mooc.fi
Programming	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Computer Science	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Artificial Intelligence	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Automation	Yes	Yes	Yes	Yes	No	No	No	No
Cloud Computing	Yes	Yes	Yes	Yes	Yes	No	No	No
User Experience & Interfaces	Yes	Yes	Yes	Yes	Yes	No	No	No
Blockchain	Yes	Yes	Yes	Yes	No	No	No	No
Cybersecurity	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Architecture	Yes	Yes	Yes	Yes	No	No	No	No
Software Business	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Data Science & Analytics	Yes	Yes	Yes	Yes	Yes	No	No	Yes

Table 2: Analysis of course themes on MOOC platforms

Of the eleven selected IT themes, the most popular was computer science MOOC courses, which were on every platform. This was to be expected as it is one of the cornerstones of IT education worldwide. The next most popular were programming and cyber security with only a single platform without education around the topics on hand. Of these two, cyber security was a surprise, outperforming both cloud computing and data science. The worst result in the comparison was a tie between Automation, Architecture, and Blockchain, with half of the platforms having MOOC courses related to the themes.

4.1.3 Platform-specific differences

EdX has been able to gather a compelling selection of IT-related courses. With the third-largest selection of courses, the platform has a broad selection of skills for users to learn. From the categorization of IT courses, the platform managed to include all categories of courses. The most popular courses on edX are basic introductory courses to computer science and programming. Much like edX, Coursera has a wide selection of computer science-related courses. However, instead of any specialization, Coursera has a general approach to the library of courses. Unlike edX, the most popular IT-related course is Stanford

University's Machine Learning (ML) course. This is followed by other machine learning and data science courses.

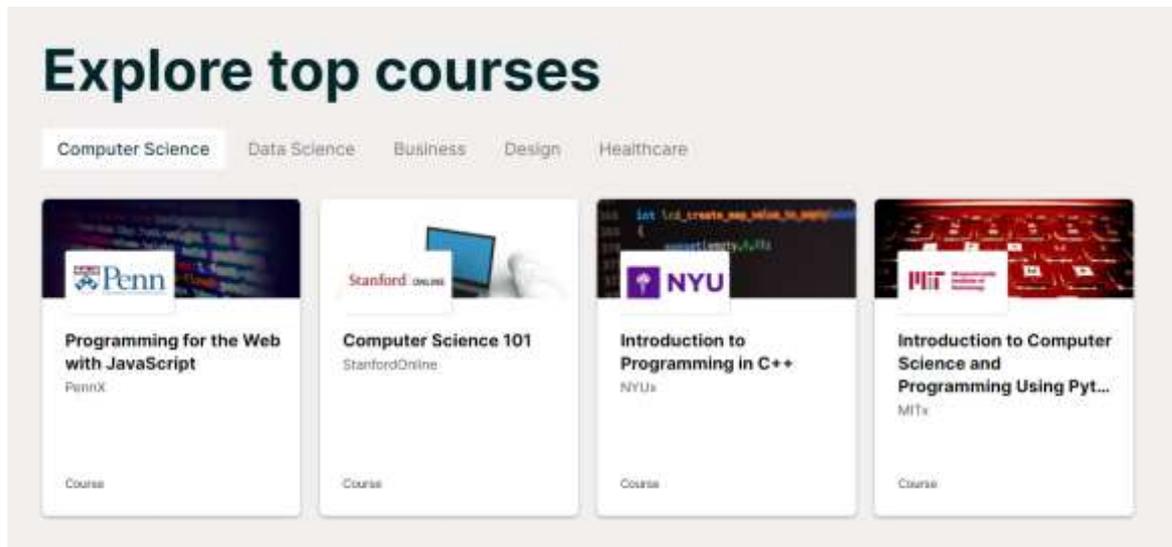


Figure 10. Most popular courses on edX

Udemy specializes in video-based MOOC courses instead of text-based. These video-based courses are taught mainly through individuals rather than universities and corporations. As most of the courses start from 10 euros, the price is quite striking, considering that most certifications have little to no value. Furthermore, on Udemy, the customer pays for the education, unlike other MOOC platforms, where the education is mostly free, and the costs are related to the certification of completion. The most popular categories on Udemy are introductory programming courses, certification training, and basic courses in data science, machine learning, and cyber security. Of these, python-related courses have over 30 million learners worldwide.



Figure 11. Popular themes on Udemy

Udacity, FutureLearn & mooc.fi are similar to larger platforms where most IT-related courses are entry-level programming courses. However, the number of more specialized courses varies. Udacity has an extensive selection of courses, though most categories have only a few courses related to the subject. The same can be said of FutureLearn and mooc.fi, though they are missing more niche themes around blockchain and automation. Despite consisting of mainly programming courses, artificial intelligence and machine learning courses are very popular on the platforms. Of the three MOOC providers, only Udacity does not have the most popular course related to AI or ML, and even then, it is the second most popular.

Of all the platforms Khan Academy and Iversity have the worst selection of courses objectively. Khan Academy focuses on educating children over the age of six, severely hindering the type of courses they offer. Introductory courses on programming and cyber security can be found for high school and college-level students. However, intermediate, and expert level students will not find suitable courses for their development. Iversity, on the other hand, offers general courses on IT and computer science but lacks even the most fundamental programming courses.

4.2 Analysis of technical capabilities

The research showed that the technical capabilities of MOOC platforms vary largely between different platforms.

All the platforms were built on a browser-based solution. This was their primary channel to deliver learning content to the users. The websites were designed to be responsive to allow learning through mobile devices in addition to traditional desktops. None of the MOOC providers limited the features exclusive to desktop view and using the platform in a mobile resolution provided the full suite of functionalities. Some of the MOOC providers have dedicated mobile applications as an alternative way to use the platform on a mobile device. The applications are available on iOS and Android free of charge. The mobile applications feature offers the same set of basic features. The applications are almost exclusively developed by larger MOOC providers with extensive funding and libraries of content.

	edX	Coursera	Udemy	Udacity	FutureLearn	Khan Academy	Iiversity	Moc.fi
Browser-based solution	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mobile application	Yes	Yes	Yes	No	No	Yes	No	No
Responsive website	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quizzes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Text	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Video playback	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Attachments & Downloads	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Live teaching and -events	Yes	Yes	No	Yes	Yes	No	No	Yes
Peer reviews	Yes	Yes	No	No	Yes	No	Yes	No
Grading	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Table 3: Analysis of features on MOOC platforms 1/2

The MOOC course content on all platforms was delivered through a combination of text, video, and exercises. All the MOOC platforms supported the use of text-based information to be added to individual courses. Researching video-based learning provided the same result. However, the approaches to how the videos were included on the platform differed. Some providers such as Khan Academy and mooc.fi embedded public or unlisted videos

hosted on YouTube onto the course compared to the more traditional hosting of the videos on the platform itself. Though a minor difference, it has implications for how the subtitles and captions were considered while designing the course. Khan Academy had subtitles similarly to the rest of the platforms, but mooc.fi has not implemented this feature. Some of the videos on Iversity have subtitles, whereas mooc.fi lacked all types of subtitles. An alternative video-based learning feature was live-streamed lectures and events. This feature aims to emulate the classroom experience on scheduled MOOC courses. The platforms most reliant on video-based learning did not support this feature. Udemy and Khan Academy have most of their courses pre-recorded in video format and embraced self-paced learning. An exception to this is Iversity that was primarily text-based learning, without the functionality of live events.

	edX	Coursera	Udemy	Udacity	FutureLearn	Khan Academy	Iversity	Mooc.fi
Polls & Surveys	Yes	Yes	No	Yes	Yes	No	No	No
File submissions	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Discussion forums	Yes	Yes	No	Yes	Yes	Yes	Yes	Partly
Wiki pages	Yes	Yes	No	Yes	Yes	No	No	Yes
Course certification	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Subtitles & Captions	Yes	Yes	Yes	Yes	Yes	Yes	Partly	No
Exams	Yes	Yes	Partly	Yes	Yes	No	Yes	No
Proctored Exams	Yes	Yes	No	Partly	No	No	Yes	No
Course Messages	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Code Execution	Yes	Yes	Yes	Yes	No	Yes	No	Yes

Table 4: Analysis of features on MOOC platforms 2/2

The MOOC platforms offered a wide selection of different types of exercises to test the users. The most popular type of exercise was quizzes based on the learning material. Every MOOC provider supported this basic functionality. However, a variation of this was more uncommon on the platforms. The lecturer's different types of polls and surveys to the learners were supported only by edX, Coursera, Udacity, and FutureLearn. Unlike the quizzes, which primarily aim to measure how well the user has digested the information, surveys act as a feedback channel to the course organizer. They were also used in conjunction with live teaching events to activate the audience. Exercises included free-form exercises and larger

projects, which could not be submitted in the form of a quiz. For these types of exercises, the platforms offered textboxes to submit free form text. Another method was to allow submitting files, which allowed a more diverse set of exercises. Again, this functionality was present on all platforms except Khan Academy and FutureLearn. These platforms instead had the more common functionality of adding text to the exercises.

IT and Computer Science-related courses had a particular type of exercises compared to other types of MOOC courses. These can be categorized as programming exercises, and they are more challenging to implement than other types of exercises. The user must be allowed to write code inside the platform, and the code must be tested to evaluate whether it is outputting a correct result. The platforms approached this problem using integrations to tools that provide such functionality. For example, mooc.fi used a Test My Code (TMC) system to allow the user submitted code to be tested on the platform. However, executing code in such a manner was not supported by FutureLearn and Iversity. Instead, FutureLearn and Iversity had a theoretical approach to the contents of the course, focusing more on quizzes.

Many of the platforms had features to support collaboration between learners. A popular approach to this was a discussion forum on the MOOC course to discuss various topics. Most MOOC platforms implemented this as a separate section that was accessed from the courses menu. FutureLearn had a different approach where the discussion forum was at the end of every chapter. Mooc.fi partly implemented this approach, where the courses had dedicated discussion forums, but they were hosted on a separate platform outside the MOOC course. Of all the platforms, Udemy did not have any type of discussion forum. Another common communication feature was course messages, which are a primary communication channel between the course instructor and participants. Of the channels mooc.fi and Khan Academy did not have this functionality. A typical collaboration feature from other online and traditional learning is peer reviews. This allows the participants to evaluate and learn from each other's exercise answers. This, however, was not a very popular feature, with half of the MOOC platforms supporting this. Platforms most orientated towards self-paced learning, such as Udemy, Khan Academy, and mooc.fi lacked this feature. This is most likely due to the uncertainty of other users participating and completing the course simultaneously.

Udacity, on the other hand, has thousands of hired assistants grading assignments; therefore, no such feature is needed.

Course materials are mainly delivered through the text and videos on the platform, but there are other resources for the user to access. A common feature is additional learning attachments such as PowerPoint presentations, exercise templates, and course textbooks. All but Khan Academy made these materials downloadable by the user. Information can also be found on wiki pages on the subject on hand or the course information. This acts as a location to store additional information or frequently asked questions. Of all the platforms, Udemy, Khan Academy, and Iversity did not support this functionality. Finally, the last type of accessible resource is a certification of the course. Most courses provide a certification of completion that can be used to publish on social media or to claim additional student credits as a part of a degree. As Khan Academy is heavily tailored to children and teenagers, the platform does not provide certifications on their courses. This is due to the company not being an accredited school.

Many of the MOOC platforms require the user to pass the course assignments to complete the course. This is done by grading the assignments by the teacher, assistants, auto-grader, or other students. However, Udemy and Khan Academy do not support grading the course performance; but instead, they are based on completing the course whether the participant has learned the subject. Another feature to access the learning is a traditional exam. Again, Udemy and Khan Academy do not support this feature as well as mooc.fi. However, Udemy has different types of exams, which are used to evaluate the user's knowledge, but they do not affect if the user passes the course. It is a way to practice for certification exams of different technologies such as cloud services. Lastly, some platforms allow the lecturer to proctor the exams remotely. From the MOOC providers, only edX, Coursera, and Iversity have this functionality. Udacity partly supports this by having scheduled and time-constrained exams, which are monitored for plagiarism. Of all the features that were included in the comparison, this was the rarest.

4.3 Discussion

The analysis of the MOOC courses highlighted the similarity and differences of specific MOOC platforms. Larger platforms generally tended to have the largest selection of topics related to computer science. Compared to smaller MOOC providers, which lacked many of the themes included in the research. An additional factor is the number of courses per theme, which in many cases, the smaller MOOC providers had 1-5 courses per topic, where larger providers had tens or hundreds of courses from which to choose. This can be seen as problematic to smaller MOOC platforms as user adoption was proven to be lower by Lu, Bin and Yaobin (2019). A similar question can be made for the suitability of courses on smaller platforms, which do not serve a large portion of advanced learners. Ansah et al. (2020) also raise the same issue regarding all MOOCs. However, the issue is more visible on smaller MOOC platforms.

MOOC platforms with a more extensive selection of courses generally had more prestigious partners in co-creating and designing the courses for the platform. This includes ivy league universities and Fortune 500 companies. These same MOOC providers have a carefully selected portfolio of partners creating courses for them. Smaller Universities and companies have less of a probability of being allowed access to these types of platforms. This is important to recognize as the technical capabilities are tightly related to the selected platforms.

The research indicated the significant differences between the technical capabilities of the MOOC platforms. As the platform defines and limits the possibilities to which teachers and MOOC designers can innovate and create courses, the importance of the platform selection cannot be understated. Mamgain, Sharma & Goyal 2014 and Xing (2019) both indicated that the correlation between a rich and diverse selection of platform features leads to better student course performance and satisfaction. Conversely, by selecting a technology-wise inferior platform, the course creator knowingly risks creating a course that students would find less engaging, thus increasing the dropout rate.

Previously proven by Albelbisi et al. (2021), the platform's capabilities and quality broadly impact user satisfaction and long-term commitment to the platform. A subsection of features many platforms did not fully have was collaborative features. These features aim to add collaboration and thus increase user satisfaction and performance, corroborated by Gamage, Fernando & Perera (2020) and (Zhao, Wang & Sun 2020)

This raises the question around smaller MOOC platforms and their market strategies. Larger MOOC providers aim to diversify and grow the platform's capabilities to compete with each other (Taneja & Goel, 2014). This is not the case with smaller MOOC platforms, which have fallen significantly behind in technological capabilities despite existing for nearly a decade. In many cases, open-source platforms exist with similar or even superior features compared to the largest MOOC providers, as Chauhan & Goel (2020) demonstrated with open edX and Moodle. These platforms might already be familiar to lecturers from traditional online learning. Introducing a new open-source MOOC platform, in many cases, offers multiple ways how to start using it whilst being easier than creating a custom platform Peltoniemi (2020).

Overall, the research highlighted the difference clear in basic technical capabilities between platforms. Larger MOOC platforms offer a wide selection of tools and features to support the learning experience, whereas smaller MOOC platforms lack most features. This primarily impacts the type of learners the platform caters to and the type of courses the course designers can implement. Previous research indicates that larger MOOC providers and platforms offer features that lead to better user experience and satisfaction (Gamage, Fernando & Perera 2020; Zhao, Wang & Sun 2020). This in turn results in higher completion rates on MOOC courses that use a combination of these features. Another advantage of larger platforms was identified as a much broader selection of courses. By catering to a wider selection of users, the platforms are further able to attract more users.

5 Summary

The research aimed to provide a holistic view of the current state of MOOC platforms and courses. The popularity of MOOC courses has risen during the past ten years as online-based learning has been more widely adopted across the world. In recent times the effects of Covid-19 have impacted the traditional classroom experience and shifted it towards other forms of studying. MOOCs have had computer science education since their inception, and advances in the industry have set new standards to the course themes and platform capabilities to support the new technologies.

The research questions that the thesis aimed to answer were what the representation of computer science on the MOOC platforms is currently like and what are the technical capabilities of the platforms. The research was completed by analyzing selected MOOC platforms. A total of 8 MOOC platforms were included in the research, consisting of well-established market leaders such as Coursera and Udemy and smaller local platforms like mooc.fi and Iversity.

The research resulted in statistics that were analyzed and visualized using cross-tabulation. It was identified that education of computer science-related courses was very similar with the largest MOOC providers. However, smaller MOOC providers had more considerable variance depending on what subjects the provider specializes in. Entry-level computer science courses are taught widely, but specialized fields and subjects inside the IT industry are more uncommon to find on smaller platforms. The research also highlighted the stark difference in basic technical capabilities between the platforms. Larger platforms offer a wide selection of tools and features to support the learning experience, whereas smaller platforms lack most features. This primarily impacts the type of learners the platform caters to and the type of courses the course designers can implement.

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