Admitting Students through an Open Online Course in Programming: A Multi-year Analysis of Study Success

Juho Leinonen, Petri Ihantola, Antti Leinonen, Henrik Nygren,
Jaakko Kurhila, Matti Luukkainen, and Arto Hellas
firstname.lastname@helsinki.fi
University of Helsinki
Helsinki, Finland

ABSTRACT

Since 2012, part of computer science student body at the University of Helsinki has been selected by using a massively open online version of the same introductory programming course that our freshmen take. In this multi-year study, we compare study success between students accepted through the online course (MOOC intake) and students accepted through the traditional entrance exam and high school matriculation exam based intake (normal intake). Our findings indicate that the MOOC intake perform better in computer science studies when looking at completed credits and grade point average, but there is no difference when considering other courses. Retention among the MOOC intake is better than among the normal intake. Additionally, students in the MOOC intake are more likely to complete their capstone project and Bachelor's thesis in the studied time-frame. However, the MOOC intake makes the already skewed gender balance more pronounced.

CCS CONCEPTS

• **Social and professional topics → Computing education**.

KEYWORDS

admission policies, retention in computer science, intake mechanisms, MOOC, introductory programming

ACM Reference Format:
Juho Leinonen, Petri Ihantola, Antti Leinonen, Henrik Nygren, Jaakko Kurhila, Matti Luukkainen, and Arto Hellas. 2019. Admitting Students through an Open Online Course in Programming: A Multi-year Analysis of Study Success. In *International Computing Education Research Conference (ICER '19), August 12–14, 2019, Toronto, ON, Canada.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3291279.3339417

1 INTRODUCTION

Introductory programming courses are the cornerstone of computer science programs [17]. Research literature suggests that nearly one-third of students in introductory programming courses fail the course [3, 30, 35]. Reasons for failing or dropping out from the course vary, ranging from motivational factors to the complexity of the subject [7, 12, 26]. As a noticeable amount of students fail the introductory programming course, it is not surprising that computer science programs have higher than average dropout rates [25].

What if, instead of a proportion of students failing the introductory programming course, students starting at a university would have the course already completed? Would they then succeed in their studies, or would they then stumble in the subsequent courses? Completing a small part of the computer science degree before enrolling could perhaps lead to less misguided perceptions about what it means to study computer science. Moreover, having experience from a university-level course could lead to a better understanding of the workload and content of courses at the university.

Since 2012, the University of Helsinki has piloted a novel admission process where, in addition to traditional admission, prospective students have been offered a free open online introductory programming course (a MOOC) through which they can apply for a study right into the computer science degree program at the University of Helsinki. In this work, we study how students admitted through the course fare in their studies when compared to students admitted through traditional admission. We study students in terms of completed credits and weighted grade point average (GPA), and compare the proportion of students who complete their studies in time. While the MOOC discussed in this work has previously been described in [31] and studied in [14, 32], the work presented in this article is the first multi-year analysis of a MOOC as an entrance exam. The closest match to our work comes from Littenberg-Tobias and Reich [16] who analyzed students in a blended online MOOC program with a six-month on-campus visit and found that when compared to on-campus students, the online participants performed somewhat better in their studies.

This article is organized as follows. Section 2 provides a review of university admission policies and discusses retention in computer science programs. Section 3 outlines the context, data, research questions and methodology of the study. In Section 4, results of the study are presented, which are followed by a discussion of the results in Section 5. Finally, Section 6 draws the results together and outlines directions for future work.

2 BACKGROUND

2.1 University admission policies

University admission policies differ around the world. Most countries require that students have a proper background to be considered for university studies. What is considered proper varies by country, but most often around 12 years of studies in primary, middle, and high school (or equivalent) are required to apply to tertiary education. In addition to having sufficient educational background,

ICER '19, August 12–14, 2019, Toronto, ON, Canada

ACM ISBN 978-1-4503-6185-9/19/08.
https://doi.org/10.1145/3291279.3339417

there are other common data points universities may consider when deciding who to admit [1, 2, 5, 8, 9, 23]:

(1) University entrance examination (institution/study program specific)
(2) Standardized tests conducted in high school (e.g. SAT/ACT)
(3) High school grades
(4) National/universal university examination (one exam for multiple universities)
(5) Motivational letters
(6) Extracurricular activities (e.g. sports, student clubs, etc.)
(7) Recommendation letters (e.g. by high school teachers)

These measure different things, and it is common that universities consider a combination of the above in their admission decisions. For example, comparing high school grades and an entrance examination, it could be argued that high school grades measure persistence as they are usually based on performance over a longer time period than an entrance examination. On the other hand, considering only high school grades could be unfair to students who did not perform well in high school, but have since improved and would perform well in an entrance examination. Additionally, an entrance examination can measure specific knowledge and skills that may not be inferred based on high school grades.

The structure of university studies can differ between countries. For example, in Europe, it is common that students apply to a certain study program or major directly, whereas in the United States, students often choose their major subject later in their studies, e.g. after their first academic year.

2.1.1 United States. University admission policies vary based on the institution. Most consider high school grades and/or standardized test scores such as scores from ACT or SAT [23]. However, many colleges consider non-merit-based factors in their decisions. For example, Harvard college states that "*While academic accomplishment is important, the Admissions Committee considers many other factors–strong personal qualities, special talents or excellences of all kinds, perspectives formed by unusual personal circumstances, and the ability to take advantage of available resources and opportunities.*"[1] Similarly, for example the University of North Carolina states that "*We don't judge a book by its cover. Or its test scores.*"[2]. While there is no national college entrance examination in the US, there are a few "universal application" services in which students can apply to multiple universities with a single application. Such services include e.g. Coalition for College Access[3], Universal College Application[4], and The Common Application[5].

2.1.2 Asia. University admission in Asia varies by country [8]. In India [8], university studies are often conducted in English, and thus good command of English is required to attend. Universities consider high school grades and might also require that students have taken certain subjects in high school to be considered – for example, when applying to a science program, a student has to have taken science studies in high school as well. In China [2], high school students take a National College Entrance Exam (NCEE) and rank universities based on their preference. Depending on the province, students may rank universities before or after the NCEE. University admissions take both the preference and students' score in NCEE into account in their decision. At least previously, universities have also conducted a "political assessment" and physical examination and considered those as well [8]. Similar to China, Japan has a national college entrance exam. In Japan, some universities (usually the top-ranked ones) can have additional exams on top of the national entrance exam – students are invited to these additional exams based on their score in the national entrance exam [1]. Many countries in Asia also have open universities that have less strict requirements about admissions [8].

2.1.3 Europe. University admission in Europe varies by country. The amount of students admitted to a certain discipline can be decided either by the university or by public authorities [5]. This is due to many universities being publicly funded. In most European countries, universities can decide admission criteria freely [5] – these countries include e.g. the UK, Sweden, Norway, Finland and Ireland. In some, only scores from a national exam usually conducted at the end of high school are considered [5] – these countries include e.g. Denmark and Poland. In some, students who have graduated from high school are free to attend universities without any additional requirements [5] – this is the case in e.g. France, Italy, the Netherlands and Spain. Some use a hybrid system where depending on the discipline, students are either freely admitted or an additional exam is required [5] – this is the case in e.g. Germany. Some German institutions may require students to have worked in the field of study before admission [9]. Altogether, free admission is more common in Southern Europe, whereas merit-based admission is more common in Northern Europe [9]. In some universities, especially those with free admission, students may also be ex-matriculated, i.e. expelled from their studies, if they do not perform well[6] – this is common in, for example, Germany, where poor performance can be determined, again for example, by repeated failed exams.

2.1.4 Finland (this study). University admissions are usually based on the Finnish matriculation exam, which includes subject-based standardized tests that students complete during the last year of their high school studies, an entrance exam, or a combination of both. When this study was conducted, entrance exams played a significant role in the admission process. However, in recent years, the role of entrance exams has been reduced in favour of the matriculation exam. In both cases, the process is merit-based and extracurricular activities do not affect the selection process. Finland has 14 universities, which are independent entities funded by the government.

2.1.5 Online courses as admission mechanisms. Analyzing the same intake mechanism of this article, Vihavainen et al. [32] compared the first cohort of students admitted through a MOOC with students admitted through traditional intake. In the preliminary work, MOOC students' performance was at least on par with other students. More recently, Littenberg-Tobias and Reich [16] studied the difference in study performance between students admitted through MOOCs and traditional students in a master's program. Students admitted through MOOCs completed their master's program in a

[1]https://college.harvard.edu/admissions/apply
[2]https://admissions.unc.edu/apply/how-we-review-test-scores/
[3]http://www.coalitionforcollegeaccess.org/
[4]https://www.universalcollegeapp.com/
[5]https://www.commonapp.org/
[6]https://www.uni-hohenheim.de/en/exmatriculation

blended environment, where part of the studies were residential and part were provided online. Students in the blended program with a MOOC intake had a slightly higher GPA than the students in the residential-only program. Additionally, students admitted through MOOCs were older than those admitted traditionally.

Both Vihavainen et al. [32] and Littenberg-Tobias and Reich [16] observed that students admitted through a MOOC were less likely to drop out during their first year of studies. This could be explained by a self-selection effect: MOOCs – which can be seen as curriculum-samping tests – provide insight into what studying the subject is like, making it possible for students to make an informed decision regarding their studies before commitment [22].

2.2 Retention in computer science programs

Graduation rates in STEM subjects have room to improve. For example, in the US, fewer than 40% of students who enter college intending to complete a degree in a STEM field actually complete a STEM degree [25]. Computer science is among the STEM subjects with lowest graduation rates – in 2002-2003, 24.6% of the students who majored in computer science completed a STEM degree [25]. Articles reporting student graduation rates from across the world are challenging to come by, perhaps due to the graduation rates not showing universities and colleges in a positive light. Several articles discuss minorities, however, for whom the graduation rates are typically even lower than for the mainstream population [13].

The dropouts in computer science are spread throughout the degree, though many drop out already during or after the first year of studies [15, 29]. One of the points where students may decide to drop out of computer science is the introductory programming course [29]. Here, reasons for dropping out include lack of time, lack of motivation, difficulty, lack of help, and not fitting in [12], as well as missing meaningful study strategies and prioritization [26]. While looking only at the introductory programming course provides a one-sided view to the broader issue of retention, focused teaching effort in the course may lead to improved study success in subsequent courses [11]. On the other hand, even if students pass the course, it is possible that they have failed to learn the skills that are expected of them [19].

While the introductory programming course has received plenty of attention, the reasons for students dropping out from computer science programs have not been extensively studied across the world. Many hypotheses that could explain the high dropout rates exist (e.g. [24]) – allegedly many of the dropouts are due to students not understanding the effort that studying takes and what the studies are like.

3 CONTEXT AND METHODOLOGY

3.1 University and context

The study has been conducted at the computer science (CS) department of the University of Helsinki, a European research-first university. Students who enter the university choose their major when applying and are admitted to a combined Bachelor's and Master's degree program.

Traditionally, admission to the CS department has been granted based on an entrance exam, a national high school matriculation exam, or a combination of both. Additionally, some students have been admitted as transfer students from other majors (e.g. mathematics) and a few through successfully completing 25 credits worth of CS studies at the open university. We will refer to these intake mechanisms as *traditional admission/normal intake* in this work.

Students are expected to complete the Bachelor's degree during the first three years, after which students can continue towards a two years Masters's program. The degrees together are composed of 180 + 120 ECTS[7] credits. Even though the target graduation time is three years for the Bachelor's degree, graduation times are typically longer.

There are no tuition fees and students receive financial aid from the government. In addition, students receive benefits such as subsidized public transport, and are eligible for low-cost housing. The benefits are tied to the study right and some of the benefits, such as the financial aid, expect a certain study pace. On the other hand, for example the low-cost housing is not always tied to study progress, and as such, it may be beneficial for students to retain their study right even if they are studying only part-time.

While the national funding model encourages studying, it also provides guidelines for universities. Approximately 40% of the universities' public funding comes from completed degrees and students progressing at an expected pace. As such, every university is seeking to find ways to identify and attract high-performing students. The MOOC, offered since 2012, through which students can be admitted to the University of Helsinki is one such effort.

3.2 Course and admission process

The course is organized as a semester-long massive open online course (MOOC) that anyone can attend, and is offered during each spring. Content-wise, the course is an exact replica of the first-semester introductory programming course that CS freshmen at the University of Helsinki take. The course covers topics typical to many introductory programming courses using a learning-by-doing approach called Extreme Apprenticeship method [33], which emphasizes practice and continuous feedback. Practice is realized through a large quantity of programming assignments; during each course week, students are expected to complete dozens of programming assignments. The assignments and the course material are structured so that theory and practice are interleaved – new topics are practiced using multiple programming assignments, where the first ones are straightforward to complete and the latter ones are larger and integrate new content with previously practiced content.

Continuous feedback in the course is provided through two different mechanisms. First, students are supported through an automated assessment service called Test My Code [34], which provides a plugin to the integrated development environment (IDE) that students use. The plugin supports integrating test-based step-by-step guidelines into programming assignments, which then provide students feedback in their programming process. Second, students can attend and ask questions in an online chat room that has course personnel, course attendants, and "MOOC-alumni", who have previously attended the course [20].

Students who apply for a study right through the MOOC have to complete at least 90% of the programming assignments each

[7]European Credit Transfer System, each ECTS corresponds to approximately 25-30 hours of studying

week during the semester[8]. Everyone who completes the required amount of programming assignments is invited to an exam.

The exam is conducted on campus, where students receive one or more programming tasks similar to the ones completed during the course. Typically 2-3 hours has been reserved for the programming part, albeit this has varied annually. In addition, each student has a personal 20-30 minute interview with two faculty members. The interview examines the student's willingness to start university studies. Admission is based on performance in the course, performance in the programming tasks in the exam, and the interview, with most emphasis on exam performance. Annually, up to approximately 50 students have been admitted through the online programming course, although in 2014, this was momentarily increased to 80 due to a national call for admitting more students.

3.3 Data

In 2012, around 400 prospective students attended the course, of whom around 50 attended the exam. Almost everyone who attended the exam was given the right to study, while in 2015, there were already around 1000 participants, of whom around 120 attended the exam. Around 50 students were accepted to the university through the MOOC in 2015. Additionally, approximately 180 students have been admitted annually through the normal intake.

We collected the study transcripts of all students who received a CS study right between 2012 and 2015 in the main autumn intake, including students admitted through the MOOC and other admission mechanisms (matriculation exam, entrance exam, and so on). The data contains students' basic demographic information (gender, year of birth) and the record of all the courses that the students have completed (between Fall 2012 and 13th of March, 2019). Yearly intake statistics are provided in Table 1, which also includes statistics on intake based on gender. Over the studied period, 8.0% of the students in the MOOC intake were women, while 22.4% of the normal intake were women. Intake data from 2016-2018 was omitted from the analysis as all intake mechanisms throughout the University of Helsinki have changed to significantly favor those with no previous study right at any university or college.

Table 1: Yearly intake statistics between the MOOC intake and the normal intake. The proportions of women from the yearly intakes are in parenthesis.

year	mooc	normal	all
2012	39 (10.3%)	179 (21.8%)	218 (19.7%)
2013	49 (4.1%)	183 (21.9%)	232 (18.1%)
2014	84 (9.5%)	200 (24.0%)	284 (19.7%)
2015	53 (7.6%)	194 (21.6%)	247 (18.6%)
All	225 (8.0%)	756 (22.4%)	981 (19.1%)

Courses are typically graded on a scale from 0 to 5 with 1 to 5 being passing grades, although a minority of courses is graded just passed or failed. Whether failed courses are recorded to the academic records varies from course to course, so we focus on passed courses only. Courses are most often worth 5 ECTS credits and full time students are expected to take six courses each semester.

[8] In 2012, the limit was 80%; in 2012 and 2013 the semester length was 12 weeks, while since 2014, the semester length has been 14 weeks.

3.4 Research questions and approach

Our research questions for this study are as follows:

- RQ1. How do the demographics of the MOOC intake differ from the normal intake?
- RQ2. How does the MOOC intake perform in their studies when compared to the normal intake?
- RQ3. Comparing the MOOC intake and the normal intake, what proportion of students complete the end of degree studies?

The analysis is quantitative, focusing on demographics and study transcripts of the intake mechanisms. We refer to the students admitted through the open online course as *MOOC intake* and students admitted through the traditional admission procedure as *normal intake*.

We compare the amount of credits gained and the weighted grade point averages (GPAs) during the first four years of study between the normal intake and the MOOC intake. We compare separately computer science studies, mathematics (a mandatory minor for CS students), and other studies. Moreover, we further investigate the number of students who complete their end of degree studies (a capstone project and Bachelor's thesis) during their first four years, and also study whether the intake influences the time that it takes to complete the Bachelor's degree.

While the expected graduation time for the Bachelor's degree at the University of Helsinki is three years, we examine the first four years since many students have responsibilities such as mandatory military service which delay graduation.

Course transcript data used in the analysis contains only those studies that have been completed since the start of the studies (i.e. start of first semester). This means that the introductory programming course (10 ECTS in total) was omitted from the MOOC intake. In addition, any possible credit transfers from past studies are omitted for both intakes.

For RQ1, we included the data of all the admitted students (see Table 1). For RQ2 and RQ3, we used the data of students who had completed at least some studies in the examined time frame (see Tables 2–5); data of the 2015 intake was excluded for RQ3 since at the time of the analysis, the cohort from 2015 had not yet studied for four years.

4 RESULTS

4.1 Demographics between intake groups

The average age of new students varies between 23.7 and 25.5 years, depending on the intake year. Average age of the MOOC intake and the normal intake are 23.8 years (sd=5.8) and 24.5 years (sd=6.0), respectively. An independent-samples t-test was conducted to compare students coming from the MOOC to other students and no significant difference was found (t(377.8)=-1.41, p=0.16).

A Chi-square test of independence was calculated comparing the gender distribution between different intake paths. A significant interaction was found (χ^2 = 22.236, df = 1, p<.001). The gender imbalance is stronger in the MOOC than in the normal intake.

4.2 Credits and GPA between intake groups

We used the Mann–Whitney test to compare credits and GPAs in four topic groups: computer science courses (cs), mathematics courses (math), other courses (other), and all the courses combined. We chose a non-parametric approach as the data is not normally distributed. To counteract the multiple testing problem, we applied a Bonferroni correction, with the number of comparisons set to 32 (4 topic groups * 4 year-groups * 2 variables). The number of comparisons is conservative given that the variables (credits and GPAs) between the years are highly correlated. We consider Bonferroni corrected p-values under 0.05 to be statistically significant.

In the analysis, we only consider students who have completed at least some studies within the given timeframe. For example, 194 MOOC intake students (see Table 2) had completed studies in their first year, while 198 MOOC intake students (see Table 3) had completed studies in their first two years, i.e. there are four students who started working on their studies in their second year.

The test results are provided in Tables 2, 3, 4, 5 for the first year, years 1-2, years 1-3, and years 1-4. The distributions are illustrated by providing medians and inter-quantile-ranges (IQR). The tables also contain Mann–Whitney test statistics (W), Bonferroni corrected p-values (p), and Cliff's Deltas (d) as the effect size measure. Credit counts are calculated for all, while GPA is calculated only for those who have completed numerically graded courses.

After the first year of study, shown in Table 2, the median credit count for the MOOC intake is 56.5 and 49 for the normal intake. This difference is mostly caused by the MOOC students having completed more CS credits (median 44 vs 36) as both groups have the same medians in math (5) and other credits (4). The differences between the MOOC and normal intake are statistically significant when comparing total credits gained and CS credits gained. When considering the GPAs, those admitted through the MOOC get better grades overall (median 3.92 vs 3.59) and in CS (median 4.12 vs 3.73). Both groups have the same median for math GPA (3). The differences in the total and CS GPAs are statistically significant. Despite a notable effect size (−0.47) supporting students in the normal intake being stronger than the MOOC intake in grades of other studies (median 3.17 vs 2.5), the Bonferroni corrected p-value is not significant – possibly due to a considerably smaller proportion of MOOC students working on studies in other subjects during their first year of study.

After two years of study, shown in Table 3, the MOOC intake are still leading in credits gained when considering total credits (median 86 vs 73) and CS credits (median 68 vs 53). Both intakes have approximately the same median in math (medians 10 for MOOC and 8 for normal intake), but for the other courses, those in the normal intake have completed more credits (median 5 vs 4). The differences between the groups in total credits and CS credits gained are statistically significant. When considering GPAs, the MOOC intake have better grades overall (median 3.7 vs 3.45) and in CS (median 3.92 vs 3.59). Both groups have approximately the same GPA in math (median 3 for MOOC and 2.8 for normal intake) and the normal intake have a higher median GPA for the other courses (median 3.29 vs 2.57). The differences in GPAs are statistically significant for all subjects but math.

After three years of study, shown in Table 4, the MOOC intake have still gained more credits overall (median 116 vs 95) and in CS (median 87 vs 67), and now also in math (median 18 vs 10). Both groups have the same median credits gained in other subjects (7). The differences are statistically significant for total credits, CS credits and math credits. When considering GPAs, the MOOC intake have higher GPAs overall (median 3.63 vs 3.42) and in CS (median 3.88 vs 3.52). The GPAs are approximately the same in math (median 3 for MOOC and 2.95 for the normal intake), while those in the normal intake have a higher GPA in other subjects (3.1 vs 2.88). The differences are statistically significant for the overall and CS GPAs.

After four years of study, shown in Table 5, those in the MOOC intake have gained more credits overall (median 131 vs 114.5), in CS (median 100 vs 71), and in math (median 20 vs 15). Those in the normal intake have gained slightly more credits in other subjects (median 8 vs 7). Only the difference in CS credits gained is statistically significant. When considering GPAs, those in the MOOC intake have higher GPAs overall (median 3.52 vs 3.37) and in CS (median 3.82 vs 3.5), a worse GPA in math (median 2.75 vs 2.89), and the same GPA (median 3) in other subjects. Only the difference in CS GPA is statistically significant.

Most of the differences found between the MOOC intake and the normal intake were small ($|d| < 0.33$) when considering the effect size [27].

4.3 Retention between intake groups

Looking at data from the intakes of 2012–2014, we found that of the 172 students from the MOOC intake, 21 (12%) did not complete any studies during the four year period. Of the 562 students from the normal intake, 164 (29%) did not complete any studies. Using Chi-square tests of independence to compare the proportion of students starting their studies, statistically significant difference was observed (χ^2 = 19.2, df = 1, p < .001).

Focusing on students who completed studies, i.e. 151 students from the MOOC intake and 398 students from the normal intake, we study the completion rates of the end of degree studies within the first four years of study. Comparing the proportion of students who finish the capstone project and the Bachelor's thesis during the studied time frame, we observe the following. From the MOOC intake, 74 (49%) of the students complete their capstone project, while from the normal intake, 133 (33%) of the students complete their capstone project. The difference is significant in favor of the MOOC intake (χ^2 = 10.673, df = 1, p = 0.001). Moreover, from the MOOC intake, 49 (32%) students completed the Bachelor's thesis, while the corresponding number for the normal intake is 94 (24%). The difference is significant (χ^2 = 4.0, df = 1, p = 0.046).

In addition to comparing the intake paths' completion of the capstone project and Bachelor's thesis, we compared completion times of Bachelor's degrees. Similar to the previous end of degree studies analysis, we only considered the intakes from years 2012–2014, and only consider students who had graduated in our data, i.e. before March 2019. Distributions of times in both intake groups were nearly normal. Thus, an independent-samples t-test was conducted to compare graduation times between the MOOC (M=1210 days, sd=366 days) and the normal (M=1190 days, sd=353 days) intake. There was no statistically significant difference (t = 0.39, df = 155.3, p = 0.70).

Table 2: Cumulative credit gains and GPAs after one year of study, shown based on subject and divided based on intake. Intake comparison is conducted using the Mann-Whitney test with the Bonferroni correction in this and the forthcoming tables.

		credits						GPA					
subject	intake	n	med	IQR	W	p	d	n	med	IQR	W	p	d
all	mooc	194	56.50	43.00	52095.50	0.03	0.16	193	3.92	0.95	56704.00	0.00	0.30
	normal	462	49.00	41.00				453	3.59	1.10			
cs	mooc	194	44.00	35.00	53715.50	0.00	0.20	193	4.12	0.93	55853.00	0.00	0.32
	normal	462	36.00	34.00				437	3.73	1.10			
math	mooc	194	5.00	15.00	46504.50	1.00	0.04	118	3.00	2.00	14588.00	1.00	-0.05
	normal	462	5.00	12.75				261	3.00	2.00			
other	mooc	194	4.00	3.50	41421.50	1.00	-0.08	15	2.50	1.35	404.00	0.11	-0.47
	normal	462	4.00	4.00				101	3.17	1.11			

Table 3: Cumulative credit gains and GPAs after two years of study, shown based on subject and divided based on intake.

		credits						GPA					
subject	intake	n	med	IQR	W	p	d	n	med	IQR	W	p	d
all	mooc	198	86.00	62.75	59292.00	0.00	0.19	198	3.70	0.92	60018.00	0.00	0.22
	normal	503	73.00	64.00				498	3.45	1.11			
cs	mooc	198	68.00	52.75	60838.00	0.00	0.22	198	3.92	0.89	60041.00	0.00	0.25
	normal	503	53.00	53.00				486	3.59	1.11			
math	mooc	198	10.00	20.00	55851.00	0.35	0.12	146	3.00	1.67	22729.00	1.00	-0.03
	normal	503	8.00	20.00				321	2.80	2.00			
other	mooc	198	4.00	3.00	46818.00	1.00	-0.06	31	2.57	1.02	1457.50	0.02	-0.39
	normal	503	5.00	5.00				153	3.29	1.25			

Table 4: Cumulative credit gains and GPAs after three years of study, shown based on subject and divided based on intake.

		credits						GPA					
subject	intake	n	med	IQR	W	p	d	n	med	IQR	W	p	d
all	mooc	200	116.00	94.50	58852.50	0.03	0.16	199	3.63	0.84	59307.00	0.00	0.18
	normal	507	95.00	91.50				503	3.42	1.10			
cs	mooc	200	87.00	67.00	62091.00	0.00	0.22	198	3.88	0.84	59468.00	0.00	0.22
	normal	507	67.00	67.50				492	3.52	1.15			
math	mooc	200	18.00	25.50	58922.00	0.02	0.16	155	3.00	1.57	25151.50	1.00	-0.03
	normal	507	10.00	25.00				334	2.95	1.92			
other	mooc	200	7.00	7.00	45069.50	0.64	-0.11	45	2.88	1.50	3326.50	0.41	-0.24
	normal	507	7.00	13.75				194	3.10	1.34			

5 DISCUSSION

5.1 Demographics

When looking at the demographics of the students, no statistically significant difference in student ages between the different intakes was observed. This differs from the study by Littenberg-Tobias and Reich, who found that students admitted through their MOOC were older when compared to traditional students [16]. It is possible that our result is influenced by the target group – in our context, students are recruited primarily to a Bachelor's degree program, while in the study by Littenberg-Tobias and Reich, students were recruited to a Master's program.

We also observed that gender imbalance was more pronounced in the MOOC intake. This may well be caused by the way how the MOOC is organized: the MOOC can be seen as a competition, there is no clear sense of belonging and little interaction with others, and the course may encourage the stereotype of a "loner" and "nerdy" computer scientist due to participants working at a distance – all of these may cause increased gender imbalance [4, 18, 21, 28]. Moreover, high schools in Finland rarely offer CS [14], and when offered, the courses are often offered by men and attended by men – these are then encouraged to further study CS as well as to participate in the MOOC discussed in this article.

5.2 MOOC students perform better in CS

Students admitted through the MOOC gain more CS credits throughout their studies, and also have a better GPA in CS overall.

Table 5: Cumulative credit gains and GPAs after four years of study, shown based on subject and divided based on intake. Only intakes from years 2012–2014 are included since the intake of 2015 had not yet completed four years of study when the data was examined.

		credits						GPA					
subject	intake	n	med	IQR	W	p	d	n	med	IQR	W	p	d
all	mooc	151	131.00	118.50	34451.50	0.26	0.15	151	3.52	0.92	34395.00	0.15	0.16
	normal	398	114.50	117.75				394	3.37	1.08			
cs	mooc	151	100.00	79.00	37018.00	0.00	0.23	151	3.82	0.90	35043.00	0.01	0.21
	normal	398	71.00	89.00				385	3.50	1.12			
math	mooc	151	20.00	34.00	34974.00	0.09	0.16	122	2.75	1.42	15098.50	1.00	-0.07
	normal	398	15.00	29.75				265	2.89	1.86			
other	mooc	151	7.00	10.50	25777.00	0.31	-0.14	44	3.00	1.24	3437.50	1.00	-0.06
	normal	398	8.00	25.00				167	3.00	1.38			

For the analysis, all studies that were completed outside the studied time frame were excluded, including also the 10 ECTS credits from the introductory programming course for the MOOC intake. The courses that the MOOC intake attend during their first semester are influenced by the MOOC: while the normal intake takes the introductory programming course (CS1), many in the MOOC intake take the data structures and algorithms course (CS2) which is often considered harder than the introductory programming course. In the studied context, the courses that students need to take to complete their CS degree are specific, but there is a range of CS electives. As the MOOC intake completes more credits than the normal intake, it is possible that CS electives are favored more by the MOOC intake. Moreover, while students in both intakes need to re-attend some courses due to failing them, some students from the normal intake fail the introductory programming course; there could also be more students in the normal intake who have no clear understanding of the effort that university-level studies require.

The results in combination with [22] suggest that students admitted through the MOOC may be more aware of what it means to study CS or at least the effort that studying requires. However, we have analyzed the cohorts as a whole, and as such, inferences on the suitability of a particular intake mechanism for individuals should not be made based on our results.

5.3 MOOC students perform the same in math and other subjects

When looking at the credits and GPAs in math and subjects other than CS and math, there is no clear difference between the intakes. The only statistically significant differences are that the MOOC students have gained more math credits after their first three years of study (Table 4, median of 18 vs 10) and that the normal intake has a better GPA in other subjects after the first two years of study (Table 3, median of 3.29 vs 2.57).

Some of the difference in math credits at the three year mark could be caused by more students in the MOOC intake hoping to graduate in time. In order to graduate, students are expected to complete a mandatory 25 credit mathematics minor which may well be the cause of the difference. At the four year mark, students in the normal intake may have caught up. We did not find students in the normal intake completing more studies in other subjects which was somewhat against our expectations – traditionally a small proportion of students who have applied to CS have started to study other subjects, which is possible in the studied context. It is possible that this effect still exists, but the number of students who do this is small enough that the behavior does not lead to statistically significant differences between the intakes.

When considering the MOOC, it is an introductory programming course, which effectively measures motivation towards programming and perhaps CS. It does not measure motivation towards math or other subjects. This could be the reason why there is a difference in CS credits gained and GPA, but no major differences in math and other credits gained & GPAs.

5.4 Completing end of degree studies

The end of degree studies in the Bachelor's degree consist of a group based capstone project where students produce a software product for a real customer, and the Bachelor's thesis which is completed individually. Students in the MOOC intake are more likely to complete the capstone project and the Bachelor's thesis during their first four years of study. However, the completion rates in both cohorts could be significantly improved as only 49% of the MOOC intake and 33% of the normal intake complete the capstone project in the studied time frame when focusing on the students who actually started their studies.

The low completion rate in both cohorts can be explained by a myriad of factors, ranging from many students working during their studies, some taking on an exchange year, and so on. Some notice that studying is not for them, and some stop their studies with plans to continue at a later point. We found no difference in terms of time to degree when comparing when students had completed their degree. The time to degree is a poor estimation, however, as there are no real incentives for completing the degree. Moreover, there likely exists a ceiling effect in the data.

Currently, the nationwide goal is to provide everyone the opportunity for education through financial aid and free tuition while the university funding structure attempts to direct universities to be more effective in producing graduates. Adjusting the funding model would likely change students' behavior. For example, if students had to pay tuition, they would possibly be more likely to graduate [6]. At the same time, a tuition fee would likely decrease enrollment [10] creating unwanted barriers for education.

5.5 Scope of this study

In this work, we chose to limit the analysis to course transcripts from the analyzed time frame. This means that students admitted through the MOOC have not had the 10 ECTS from the introductory programming course included in their data, while for the normal intake this is included given that the course is completed within the discussed timeframe. Out of the intakes of 2012–2014 (who had four years of studies), approximately 88% of the MOOC intake and 71% of the normal intake completed courses in their first four years. Would the analysis have included also those who did not start their studies, the MOOC intake would have had a lead in all of the studied subject areas.

In the studied context, students may take a study position and consequently also a student status, but not start their studies. Students may, for example, want to secure a study place for the future (starting the studies can be postponed almost infinitely), or want to do a second degree (they may take a study position even when holding another, although students may take only one study position each year). This unfortunately means that someone else who is looking for a study position is left out. In 2016, the way how students are admitted was changed; in the current model 80% of the offered study rights are reserved for those who previously have not held a study position.

From the perspective of the university funding coming from the government, the MOOC intake has significantly more active students than the normal intake. Moreover, students in the MOOC intake progress in their studies, on average, at a faster pace, yielding better results from the financial perspective. However, the MOOC is not a panacea as the active students from the normal intake proceed in their studies at almost comparable pace – the effect size in terms of Cliff's delta of the MOOC intake is subtle in most of the cases.

5.6 Limitations

First, the results of this study are specific to a particular context. It is likely that the field of study affects how well an online course works as an intake mechanism. In the studied context, the amount of possible applicants is limited as the course is offered in Finnish. Additionally, the structure of studies, country-specific factors such as tuition fees and student benefits as well as high demand of CS professionals in the workforce likely affect the outcomes. One should not draw conclusions on the applicability of the model in their particular context based on our results.

Second, we only examined the demographics of the students, the accumulation of credits, GPAs, and the speed of completing studies. We did not look into how students perform in specific courses and only examined differences between CS, mathematics (a mandatory minor), and other studies. It is possible that results in specific courses or within-subject areas could be different – we did not, for example, study how well the cohorts perform in e.g. mathematically intensive computer science courses.

Finally, it is possible that students had completed studies before they started in the CS program. For example, it is quite common that students from other STEM fields transfer to CS. We only considered courses completed after starting in the CS program, and thus, it is possible that a student with previous studies was considered to have gained less credits in this study if some of the credits were obtained before they started to study CS. However, such students may be admitted through all the intake mechanisms.

6 CONCLUSIONS

In this work, we examined how students admitted through an open online course perform through their undergraduate degree when compared to students admitted through traditional admission procedures. We also studied if there are differences between the intakes in terms of demographics.

To summarize, our research questions and answers to the research questions are as follows:

RQ1. How do the demographics of the MOOC intake differ from the normal intake?

Answer: There is no difference in age, but the MOOC intake has even less women than the normal intake (8% in the MOOC intake, 22.4% in the normal intake).

RQ2. How does the MOOC intake perform in their studies when compared to the normal intake?

Answer: The MOOC intake gain more credits with better GPAs in CS studies, but perform the same in other studies. However, the difference is not large.

RQ3. Comparing the MOOC intake and the normal intake, what proportion of students complete the end of degree studies?

Answer: The MOOC intake is more likely to complete their end of degree studies within the studied time frame (e.g. 49% vs 33% for the capstone project). There exists substantial room for improvement in both intakes, however.

The data indicates that using a massive open online course (MOOC) for recruitment may yield students who are more committed to their studies and consequently more likely to start their studies. Moreover, students from the MOOC intake perform better in their CS studies and are more likely to complete their end of degree studies. At the same time, the gender imbalance is more profound in the MOOC intake than in the normal intake, and there are no clear differences in the study performance between the intakes in mathematics and other studies.

While the results after the first year of studies were similar to the results after four year of studies, there were also notable differences. For example, the difference between the overall credit count and GPA was no longer statistically significant between the intakes at the four year mark. If the analysis would have focused only on the first three years, this effect would not have been observed. From the methodological point of view, this provides additional evidence for conducting multi-year analyses of intervention outcomes.

As a part of our future work, we are looking into factors that explain study performance, and are also seeking to identify and resolve issues related to the more profound gender imbalance in the MOOC. Moreover, in our present analysis we divided the intakes into two groups: the MOOC intake and the normal intake. Here, the normal intake also includes a set of students who have attended the MOOC, but have not received the study right through it. In practice, there are several sub-populations within the intakes which we will study in the future in more detail.

REFERENCES

[1] Kamal Abouchedid. 2010. Undergraduate Admissions, Equity of Access and Quality in Higher Education: An International Comparative Perspective. In *Towards an Arab higher education space: international challenges and societal responsibilities: Proceedings of the Arab Regional Conference on Higher Education*. UNESCO, 137.

[2] Muhammad Azeem Ashraf. 2014. Chinese higher education enrollment policy: Fairness of system for students' choice of university. In *2014 International Conference on Global Economy, Finance and Humanities Research (GEFHR 2014)*. Atlantis Press.

[3] Jens Bennedsen and Michael E Caspersen. 2007. Failure rates in introductory programming. *AcM SIGcSE Bulletin* 39, 2 (2007), 32–36.

[4] Sapna Cheryan, Victoria C Plaut, Caitlin Handron, and Lauren Hudson. 2013. The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex roles* 69, 1-2 (2013), 58–71.

[5] Thomas Estermann and Terhi Nokkala. 2009. *University autonomy in Europe: exploratory study*. European University Association Brussels.

[6] Pietro Garibaldi, Francesco Giavazzi, Andrea Ichino, and Enrico Rettore. 2012. College cost and time to complete a degree: Evidence from tuition discontinuities. *Review of Economics and Statistics* 94, 3 (2012), 699–711.

[7] Michail N Giannakos, Ilias O Pappas, Letizia Jaccheri, and Demetrios G Sampson. 2017. Understanding student retention in computer science education: The role of environment, gains, barriers and usefulness. *Education and Information Technologies* 22, 5 (2017), 2365–2382.

[8] Grant Harman. 1994. Student selection and admission to higher education: Policies and practices in the Asian region. *Higher Education* 27, 3 (1994), 313–339.

[9] Jean-Pierre Jallade. 1992. Undergraduate higher education in Europe: Towards a comparative perspective. *European Journal of Education* 27, 1/2 (1992), 121–144.

[10] Thomas J Kane. 2003. *A quasi-experimental estimate of the impact of financial aid on college-going*. Technical Report. National Bureau of Economic Research.

[11] Hansi Keijonen, Jaakko Kurhila, and Arto Vihavainen. 2013. Carry-on effect in extreme apprenticeship. In *2013 IEEE Frontiers in Education Conference (FIE)*. IEEE, 1150–1155.

[12] Päivi Kinnunen and Lauri Malmi. 2006. Why Students Drop out CS1 Course?. In *Proceedings of the Second International Workshop on Computing Education Research (ICER '06)*. ACM, New York, NY, USA, 97–108. https://doi.org/10.1145/1151588.1151604

[13] Robert Koenig. 2009. Minority retention rates in science are sore spot for most universities.

[14] Jaakko Kurhila and Arto Vihavainen. 2015. A purposeful MOOC to alleviate insufficient CS education in Finnish schools. *ACM Transactions on Computing Education (TOCE)* 15, 2 (2015), 10.

[15] Miriam Liston, Victor Pigott, Denise Frawley, and Dawn Carroll. 2018. A study of progression in Irish higher education: 2014/15 to 2015/16. *Dublin: Higher Education Authority* (2018).

[16] Joshua Littenberg-Tobias and Justin Reich. 2018. Evaluating Access, Quality, and Inverted Admissions in MOOC-Based Blended Degree Pathways: A Study of the MIT Supply Chain Management MicroMasters. (2018).

[17] Andrew Luxton-Reilly, Simon, Ibrahim Albluwi, Brett A. Becker, Michail Giannakos, Amruth N. Kumar, Linda Ott, James Paterson, Michael James Scott, Judy Sheard, and Claudia Szabo. 2018. Introductory Programming: A Systematic Literature Review. In *Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE 2018 Companion)*. ACM, New York, NY, USA, 55–106. https://doi.org/10.1145/3293881.3295779

[18] Allison Master, Sapna Cheryan, and Andrew N Meltzoff. 2016. Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology* 108, 3 (2016), 424.

[19] Michael McCracken, Vicki Almstrum, Danny Diaz, Mark Guzdial, Dianne Hagan, Yifat Ben-David Kolikant, Cary Laxer, Lynda Thomas, Ian Utting, and Tadeusz Wilusz. 2001. A multi-national, multi-institutional study of assessment of programming skills of first-year CS students. In *Working group reports from ITiCSE on Innovation and technology in computer science education*. ACM, 125–180.

[20] Matti Nelimarkka and Arto Vihavainen. 2015. Alumni & Tenured Participants in MOOCs: Analysis of Two Years of MOOC Discussion Channel Activity. In *Proceedings of the Second (2015) ACM Conference on Learning @ Scale (L@S '15)*. ACM, New York, NY, USA, 85–93. https://doi.org/10.1145/2724660.2724671

[21] Muriel Niederle and Lise Vesterlund. 2011. Gender and competition. *Annu. Rev. Econ.* 3, 1 (2011), 601–630.

[22] A Susan M Niessen, Rob R Meijer, and Jorge N Tendeiro. 2018. Admission testing for higher education: A multi-cohort study on the validity of high-fidelity curriculum-sampling tests. *PloS one* 13, 6 (2018), e0198746.

[23] Julie P Noble and Richard L Sawyer. 2004. Is high school GPA better than admission test scores for predicting academic success in college? *College and University* 79, 4 (2004), 17.

[24] Eva O´ Brien. 2016. Why are computer science drop-out rates so high? http://trinitynews.ie/2016/02/why-are-computer-science-drop-out-rates-so-high (accessed 2019-04-01).

[25] Steve Olson and Donna Gerardi Riordan. 2012. Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. *Executive Office of the President* (2012).

[26] Andrew Petersen, Michelle Craig, Jennifer Campbell, and Anya Tafliovich. 2016. Revisiting Why Students Drop CS1. In *Proceedings of the 16th Koli Calling International Conference on Computing Education Research (Koli Calling '16)*. ACM, New York, NY, USA, 71–80. https://doi.org/10.1145/2999541.2999552

[27] Jeanine Romano, Jeffrey D Kromrey, Jesse Coraggio, and Jeff Skowronek. 2006. Appropriate statistics for ordinal level data: Should we really be using t-test and Cohen's d for evaluating group differences on the NSSE and other surveys. In *annual meeting of the Florida Association of Institutional Research*. 1–33.

[28] Casey A Shapiro and Linda J Sax. 2011. Major selection and persistence for women in STEM. *New Directions for Institutional Research* 2011, 152 (2011), 5–18.

[29] Derbenwick Miller A. Alvarado C. Barker L. Barr V. Camp T. Frieze C. Lewis C. Cannon Mindell E. Limbird L. Richardson D. Sahami M. Villa E. Walker H. Stephenson, C. and S Zweben. 2018. *Retention in Computer Science Undergraduate Programs in the U.S.: Data Challenges and Promising Interventions*. ACM, New York, NY.

[30] Arto Vihavainen, Jonne Airaksinen, and Christopher Watson. 2014. A systematic review of approaches for teaching introductory programming and their influence on success. In *Proceedings of the tenth annual conference on International computing education research*. ACM, 19–26.

[31] Arto Vihavainen, Matti Luukkainen, and Jaakko Kurhila. 2012. Multi-faceted support for MOOC in programming. In *Proceedings of the 13th annual conference on Information technology education*. ACM, 171–176.

[32] Arto Vihavainen, Matti Luukkainen, and Jaakko Kurhila. 2013. MOOC as semester-long entrance exam. In *Proceedings of the 14th annual ACM SIGITE conference on information technology education*. ACM, 177–182.

[33] Arto Vihavainen, Matti Paksula, and Matti Luukkainen. 2011. Extreme apprenticeship method in teaching programming for beginners. In *Proceedings of the 42nd ACM technical symposium on Computer science education*. ACM, 93–98.

[34] Arto Vihavainen, Thomas Vikberg, Matti Luukkainen, and Martin Pärtel. 2013. Scaffolding students' learning using test my code. In *Proceedings of the 18th ACM conference on Innovation and technology in computer science education*. ACM, 117–122.

[35] Christopher Watson and Frederick WB Li. 2014. Failure rates in introductory programming revisited. In *Proceedings of the 2014 conference on Innovation & technology in computer science education*. ACM, 39–44.