Digital Education For All: Multi-University Study of Increasing Competent Student Admissions at Scale

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ABSTRACT

An indubitable way to put learning at scale in practice is to implement Massive Open Online Courses, or MOOCs. When a wide-enough portfolio of them is available, new applications arise. For instance, university admissions in Finland, where this study was conducted, have traditionally been based on students' grades in high school studies, an entrance examination, or a combination of both. A minority of students have been accepted through an open university admission path where students can get a study right if they complete enough university course credits with a high enough grade in a given time frame. In this work, we report results from a multi-university project in which the open university admission path has been expanded. All the universities in the Digital Education For All (DEFA) project remarkably expanded their portfolio of MOOCs that were offered both openly and for free, and the new admission path was simultaneously actively marketed and modified. In our analysis, we focus on examining whether the project increased computer science enrolments in the participating universities and how students accepted through the project perform in their studies compared to their peers accepted through other, traditional intake paths.

CCS CONCEPTS

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

KEYWORDS

MOOCs, admission policies, retention in computer science, intake mechanisms, student intake, student admissions

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1 INTRODUCTION

The fact that society needs ever more employees and experts with computer science skills manifests itself also in the increasing number of applicants to computer science study programs worldwide. Finland, where this study was conducted, is no exception. In order to be able to handle the increasing number of applicants, also in the future, the student admission system should be revised to work at scale. Moreover, the topical pandemic situation has forced special arrangements to take place because traditional physical entrance examinations have been hard and unsafe to organize. We have been able to ease these problems by a novel, alternative admission procedure that works nicely at scale.

The traditional intake mechanism to tertiary education in Finland is via a nationwide joint application system in which applicants rank up to six education providers in a decreasing order based on their interest. If they score enough entrance points for some of the education providers, they are free to enroll to the one of those within the shortlist that has the highest rank in their original list. The entrance points are based on success either in the matriculation examination taken in the final high school year or in a separate university entrance exam. The computer science entrance exam is arranged simultaneously at all universities in Finland having such a Bachelor's program and applicants are free to take the exam at

any of them independently of to which of these universities they are applying.

We argue that there are several shortcomings of this traditional intake mechanism. Firstly, it repels individuals suffering from stress in an examination situation. Secondly, as computer science has traditionally not been taught in high schools in Finland, many people either do not apply in the first place because they do not know the discipline, or later discontinue their studies having had a false impression of what computer science really is like. Thirdly, arranging physical exams for a very large number of applicants is tedious, requires special premises, and frankly too much extra labor for evaluation and rating, given that it is only a small fraction of the applicants who will eventually be given the right to enroll. Thus, the mechanism does not scale up well.

In this paper, we report initial results of a project where five research-oriented universities in Finland opened their first-year studies to the wide public and also offered an admission path through these studies. As the implementation varied from one university to another, it is interesting to study whether there are some best practices that positively correlate with students' performance in their university studies. As a side-effect, we hope that the new mechanism also has a positive effect on graduation times. In Finland, the target time for graduation from Bachelor's programs is three years and the government has built strong incentives both to the students and to the education providers to meet it. There are three main parts in the university funding model: 1) education, 2) research and 3) other education and science policy considerations that are weighted by factors 42 %, 34 %, and 24 %, respectively. Within the biggest, education part, the financial focus comes from how timely the degrees are completed. Degrees completed 1) within the target time, 2) within 12 months after the target time, 3) any time thereafter will be compensated with weighting factors of 1.5, 1.3, and 1, respectively.

Students in Finland may receive twofold financial support during their studies: a monthly grant and a government-guaranteed loan. The grant can be received for up to 30 months for the Bachelor's degree. The loan includes the governmental built-in incentive for timely graduation: students completing their degree in the target time may get their loan compensated up to a third of the grand total of the loan.

The rest of this paper is organized as follows: Section 2 discusses some related work and Section 3 describes the context of the study and the research methods used. In Section 4, we present the results of this study that are consequently discussed in Section 5. Section 6 concludes the work and outlines some future directions.

2 RELATED WORK

The usual prerequisite for tertiary education is the completion of primary and secondary education. Typical intake mechanisms include, for example, entrance exams for a specific university or program [6], national entrance exams for multiple universities at the same time [1, 2], high school grades [16], and standardized examinations (such as the SAT and ACT exams) [16]. In some cases, other factors can be considered in the admissions, such as extracurricular activities (for example, participation in student clubs) [8], motivation letters or essays [5], and recommendations [9]. All the mentioned admission policies measure different aspects of the potential students, and universities usually consider multiple aspects in their selection criteria. Some of the mentioned admission policies are objective and heavily merit-based, such as standardized tests, while others are quite subjective, such as recommendation letters.

As in many STEM (Science, Technology, Engineering, and Mathematics) fields, computer science programs tend to suffer from student dropouts [11, 17, 20]. Globally, around one third of the participating students fail the introductory programming course [3, 22], which is likely to explain some of the dropouts – students may feel frustrated and unmotivated if they do not manage to pass the course that, in most programs, is the very first they encounter. Students leaving computer science as their major may have a perception of computer science as an asocial, coding-only field [4]. Nguyen and Lewis [15] also reported in their study of first-year students from 80 computer science departments that competitive admission policies, such as requiring certain grades, negatively predict students' self-efficacy, sense of belonging, and their perception of the department they are applying to. Shapiro and Sax [19] summarize a wide range of factors that affect especially women's persistence in STEM majors, describing, for example, the effects of preparation from previous levels of education, the role of peer interactions, and interactions with teachers and faculty.

However, computer science programs have gained massive popularity both from potential students and employers [14]. Over the past decade, computer science programs have received growing numbers of applicants [14], while employers report a continuous need for professional programmers and software engineers [7]. All in all, the field would benefit from an update to the typical admission policies that give the potential applicants a clearer picture of computer science as a program and a field before they start their studies, and allow scaling the intake mechanisms for the large pool of applicants.

Outside of the scope of traditional intake mechanisms, Littenberg-Tobias and Reich [12] describe their usage of a MOOC as an entrance exam for a Master's degree program in supply chain management. The admissions were based on student performance in MOOCs and a proctored exam. In their study, Littenberg-Tobias and Reich report that students accepted through the MOOC intake receive higher grades during their studies compared to students through traditional intakes, but the MOOC intake is dominated by men. The study also noted that the MOOC intake attracted a notable number of students who already had a Master's degree.

Prior work has also evaluated different student intake mechanisms specifically in computer science. For example, Vihavainen et al. [21] have studied the use of a programming MOOC as an entrance exam. In their work, Vihavainen et al. present an intake mechanism in which students can apply for university by completing a 12-week programming MOOC with an accompanying interview. Later, Leinonen et al. [10] reported the development and long-term effects of the intake mechanism, stating that students accepted through the MOOC intake perform better in their studies than those accepted through traditional intakes. However, Leinonen et al. also report that the MOOC intake had even more skewed gender imbalance than traditional intakes, similarly to other studies [12].

In a pilot study with just a single university, Pirttinen et al. [18] describe a new, non-traditional intake mechanism for their computer science program. In this intake, students are accepted to a computer science program if they complete one academic year's worth of credits in one calendar year. All the courses are available online and free of charge, making the intake heavily motivation-based. In their study, Pirttinen et al. reported that students accepted through this intake complete more credits during their first few years with similar grades to students from other intakes, and the new intake mechanism seemed to increase the number of applicants in general.

3 METHODOLOGY

3.1 Context

The Digital Education For All (DEFA) project is a joint collaboration of five research universities to open first-year computer science courses online and for free to audiences outside of universities. Additionally, students who complete enough courses through the project can apply for a study right at any of the participating universities. The courses completed for the application are accepted as is for the degree after receiving a study right, meaning that the students accepted through the DEFA intake effectively start their studies from the second year. The project distributes funding to the participating universities for building and upgrading online courses, and for the additional resources needed to open or develop the intake mechanisms. Out of the five participating universities, four deployed either a new intake mechanism, or extended an existing one significantly, and will report the effects of the DEFA project in this study.

In Finland, students apply for a combined Bachelor's and Master's degree program, and choose their major at the time of application. The Bachelor's degree consists of 180 ECTS[1] credits with a target schedule of three years, while the Master's degree is 120 ECTS credits with a target schedule of two years. Thus, students are expected to complete approximately 60 ECTS credits each year. The first year of a computer science degree consists mostly of computer science courses with varying levels of mathematics based on each university's curriculum. The courses focus heavily on programming and introductory topics such as databases. Finnish universities are tuition-free for students from the EU/EEA (European Union/European Economic Area). Practically all the students in Bachelor's degree programs are from Finland, and thus, studying without tuition fees.

Most of the students enter the computer science program through a "main intake" that consists of two routes: a student can be accepted through an entrance exam, which is common for all the Finnish universities, or based on their high school matriculation examination grades. Besides the main intake, most computer science programs offer an "open intake", which has traditionally been based on a student's performance on a set of university-level courses. These courses have typically incurred a fee for all students regardless of their country of residence.

The DEFA project strives to offer an extension to the existing open university intake. By offering a wider variety of courses free of charge, the project hopes to reach a wider range of motivated students who wish to try computer science courses before entering university, regardless of their monetary situation.

The open university intake mechanisms differ between universities. Table 1 summarizes the differences, which are explained in more detail in the following subsections. The *time* column noted a potential time limit in which all the required courses must be completed. The *previous study right* column specifies whether a student's previous university study right affects their possibility of getting accepted. The *eligibility* column refers to whether a student is required to have a high school diploma in order to get accepted through the open intake mechanisms.

3.1.1 University of Oulu. In the University of Oulu, there is no separate DEFA selection criteria. All DEFA students are accepted as part of the normal Open University path, which belongs to the main intake. The selection criteria has been the same during the duration of the project: An applicant must have at least 15 ECTS credits (that is, three courses) of any computer science courses that correspond to the studies in the applied Bachelor's program. The courses may have been completed in other Finnish universities, including those that are participating in the DEFA project. At least five credits (i.e. one course) must be programming. The threshold and ordering score for the selection is counted by multiplying the grade (1 to 5) with the course credits. The minimum accepted score is 45 points, meaning that if an applicant has received 15 ECTS credits, the average grade must be 3, but if a student is taking more courses, also lower grades may award a study place.

As seen in the first row of Table 1, the DEFA intake in the University of Oulu has no acceptance quota, so any student who passes the admission criteria is accepted. Student's possible existing study right to another program or university does not affect their eligibility, nor the year when they completed the required courses; however, students must have a high school diploma or equivalent.

University of Oulu has provided seven open university courses (five credits each) during the period of this research. All of those were available through the DEFA project, and five of those were improved with the provided funding.

3.1.2 University of Jyväskylä. University of Jyväskylä is the second largest educator of Bachelor's and Master's graduates in the field of ICT in Finland. While the university has multiple ICT-related programs, this research concentrates on the mathematical information technology program, which is the closest equivalent of a traditional computer science program (rather than an engineering program). Students are accepted to the program twice a year.

The DEFA selection criterion has varied during the duration of the project, consisting of 9-16 ECTS credits of courses outlined in the admission criteria for the DEFA selection. As the DEFA project started in the autumn semester of 2018, and it was possible to complete DEFA studies during the autumn period, it was possible to start as a degree program student via the DEFA intake already in January 2019.

In 2018, admission criteria consisted of two courses: programming and data networks (9 ECTS credits in total). In 2019, the admission criteria was extended into 16 ECTS credits consisting four courses: computer and data networks as tools, programming, data networks and web design. A grade requirement remained the

[1] *European Credit Transfer and Accumulation System*, in which each credit corresponds to approximately 27 hours of work, and 60 ECTS credits to a full year of studies.

University	Credits required	GPA required	Specified courses	Time	Acceptance quota	Previous study right	Eligibility
Uni. Oulu	15	3.0/5.0	No	No limits	Everyone accepted	No limit	Yes
Uni. Jyväskylä	16 (9*)	3.0/5.0 for each course	Yes	No limits	Everyone accepted	No limit	No
Uni. Turku	23	3.0/5.0	Yes; partially	No limits	~25 accepted by GPA	No limit†	No
Uni. Helsinki (DEFA)	60 (50*)	No requirements	Yes; partially	1 year	Everyone accepted	Limit	No
Uni. Helsinki (open uni.)	25	3.5/5.0	Yes	3 years	Everyone accepted	Limit	No

Table 1: *: For the first year of the project. †: Students without existing study rights prioritized. The *time* column noted a potential time limit in which all the required courses must be completed. The *previous study right* column specifies whether student's previous university study right affects their possibility of getting accepted. The *eligibility* column refers to whether a student is required to have a high school diploma in order to get accepted through the open intake mechanisms.

same throughout the project: an applicant had to receive at least a grade of 3/5 from each of the courses. There was no time limit for the completion of the courses, and every student who completed the requirements was accepted to the program. As seen in the second row of Table 1, previous study rights do not affect the admission, and students are not required to have a high school diploma in order to get accepted through this specific intake.

In addition to the courses mentioned above, the University of Jyväskylä has also offered other, varying courses through the DEFA project. Participating students initially paid for the courses, but the payment was refunded after completing the course and completing a refund request. All the available courses were offered to high school students for free.

3.1.3 University of Turku. University of Turku is the second largest university in Southwest Finland. The open university intake, which has existed in computer science since 1995 and was extended during the DEFA project, accepts 5 to 25 applicants each year based on the completion of 18-25 ECTS credits.

During the DEFA project's duration, there have been three different options in the open university intake: 1) 23 ECTS credits with selected courses from the university's open course selection with a minimum GPA of 3.0/5.0, 2) 23 ECTS credits from the DEFA studies with a minimum GPA of 3.0/5.0, or 3) 25 ECTS credits from any open university studies. The first option includes two compulsory courses, Introduction to Programming (5 ECTS), and Introduction to Object Oriented Programming (5 ECTS). The last option consists of any 25 applicable ECTS credits, and each applicant's studies will be evaluated by a faculty member individually to ensure the applicability.

In addition, the priority in the open university intake is given to those applicants who do not have an existing tertiary education degree or an active study right in any Finnish university, as seen on the third row of Table 1. There is no time limit to the completion of the required studies.

3.1.4 University of Helsinki. University of Helsinki is the largest university in Finland. The first year of the Bachelor's degree in computer science consists mostly of computer science and mathematics courses with a heavy focus on programming and introductory topics such as databases.

Most students enter the computer science program through the "main intake", which consists of two possible intake routes: an entrance exam or high school matriculation examination grades. The open university intake, seen on row 4 in Table 1, requires students to complete 25 ECTS credits with a minimum GPA of 3.5/5.0. The DEFA project and its intake extend and modify this intake mechanism.

Through the DEFA project, University D offers the right to enroll to any student completing 50 (only in the first year of the project) or 60 credits of the MOOC courses from the DEFA project within a calendar year (see Table 1, row 4). This corresponds to a full year of studies (in terms of the expected ECTS credits completed). There are no grade average requirements – instead, the students have to complete the required number of credits in one calendar year, allowing them to complete courses from the beginning of July until the end of June.

For the University of Helsiki, students who have an existing study right in any Finnish tertiary education program are not eligible for admission through the open university or the DEFA intake. A student with an existing study right must either complete their current studies or give up their previous study right before the application period in order to be considered. However, applicants are not required to have a high school diploma or equivalent in order to apply.

3.2 Data

The data used for this study consists of study records containing all the courses a student has taken in a participating university. From this data, we examine the credits and grades accumulated during the first two years of studies for students who have been accepted to the computer science program in 2019 or 2020. Credits consist of all completed courses, while GPA calculations only take into account courses that were graded on a numerical 1-5 scale, and not on an accepted/failed scale. All the universities were provided a script that handled all the statistical calculations in order to make sure that the results are reported in the same way. The universities formatted their own data sets into the format accepted by the script, and only reported the results for common use. For application and acceptance rates, as well as student demographics, we look at students accepted in 2019, 2020, and 2021.

As an exception, the University of Jyväskylä has two admission periods in a year, in both the fall and the spring semester, whereas all the other universities only admit new students at the beginning of the fall semester. For the cohort of students from the University of Jyväskylä who started in January, the years were calculated as calendar years (January to December), while in all the other cases, a year is measured as an academic year (September to August).

University of Helsinki reports the open university intake and the DEFA intake as separate mechanisms, as their admission policies are vastly different, as described in Section 3.1.4. For the reported

	Year			
Uni. Oulu intake	**2018**	**2019**	**2020**	**2021**
Main	90 (345)	94 (471)	99 (465)	136 (481)
DEFA	3 (3)	5 (9)	15 (21)	14 (22)

Table 2: Number of students accepted (and applied) to the University of Oulu through each intake in 2018-2021.

	Year			
Uni. Jyväskylä intake	**2018**	**2019**	**2020**	**2021**
Main	219 (683)	181 (746)	110 (735)	54 (585)
DEFA	26 (50)	26 (50)	28 (51)	22 (61)

Table 3: Number of students accepted (and applied) to the University of Jyväskylä through each intake in 2018-2021.

	Year			
Uni. Turku intake	**2018**	**2019**	**2020**	**2021**
Main	45 (474)	45 (536)	85 (559)	85 (581)
DEFA	8 (11)	15 (40)	21 (29)	25 (56)

Table 4: Number of students accepted (and applied) to the University of Turku through each intake in 2018-2021.

	Year			
Uni. Helsinki intake	**2018**	**2019**	**2020**	**2021**
Main	168 (1256)	179 (1623)	183 (1689)	193 (1281)
Open uni.	28 (31)	63 (85)	72 (98)	128 (161)
DEFA	n/a	19 (85)	16 (98)	17 (161)

Table 5: Number of students accepted (and applied) to the University of Helsinki through each intake in 2018-2021. DEFA intake is not available for the year 2018.

credits and GPAs, only the University of Helsinki DEFA intake includes the courses completed before university admission, as the intake requirements essentially act as the first study year. From the other DEFA intake credits and GPAs, as well as the University of Helsinki open university intake, approximately 9-25 credits worth of course records are not taken into account in the results as these were completed before the students formally started their studies in a university program. This is further discussed in Section 5.

3.3 Research Methods

Our research questions are as follows:

RQ1. How did the DEFA project affect student intake in general?
RQ2. How do students accepted through the DEFA project perform in their studies compared to students accepted through other intake mechanisms?
RQ3. Do the demographics of students accepted through the DEFA project differ from the general student population?

Our research is based on a quantitative analysis of the intake reports and study transcripts.

For RQ1, we report and analyze the number of applied and accepted students for our computer science programs before and during the DEFA project.

For RQ2, we compare the average credits and GPAs of students from the DEFA intake to the main intake within each university. We apply the Mann-Whitney U test to examine whether the differences between intakes are statistically significant.

For RQ3, we inspect the age and gender demographics, and compare the differences between intakes. We apply Mann-Whitney U test to examine whether the differences in ages are statistically significant between intakes, and Chi-squared test to investigate whether the differences in gender distributions between intakes are statistically significant.

4 RESULTS

4.1 Effect on Student Intake

4.1.1 University of Oulu. In the University of Oulu, the number of applicants has increased during the years 2018-2021 up to 45 %. The DEFA project has significantly increased the popularity of the open intake mechanism, as seen in Table 2. The open university intake previously had just a handful of applicants each year, typically advanced high school students who completed university-level courses in advance. While the admission quota had been set at 5 study places, it was never filled.

A significant increase can be seen in 2020: the number of applicants in the DEFA intake was 21, and the number of accepted students was 15. At the same time, the acceptance quota was increased to up to 35 study places in order to make sure that all applicants fulfilling the selection criteria may be taken in. The positive effect of the DEFA project was also seen in the open university courses where the number of students increased by several hundred percents.

4.1.2 University of Jyväskylä. In the University of Jyväskylä, the number of applicants has increased from 683 to 746 in the main intake between 2018 and 2019. Since 2019, both the number of applying students and the number of accepted students has decreased in the main intake, while the number of applicants in the DEFA intake has slightly increased, as seen in Table 3. More specifically, the number of accepted students in the DEFA intake slightly increased between 2019 and 2020 (from 26 to 28), but decreased in the year 2021 (from 28 to 22).

4.1.3 University of Turku. The number of applicants has increased in the University of Turku in both the main and the DEFA intake, as seen in Table 4. The increased popularity has put pressure on increasing the acceptance quota for both of the intake mechanisms. In 2020, the intake quota was increased by 40 students for the main intake, but the intake is still hindered by high pressure: there are more than seven applicants for each study place in the main intake. The number of applicants has also increased in the DEFA intake, from 11 before the project, to 56 during the project. The number of accepted students through the DEFA intake is capped due to the acceptance quota.

4.1.4 University of Helsinki. While the number of both applicants and accepted students in the University of Helsinki has been rising even before the project, the effects of the DEFA project can be clearly seen from 2019 intake onwards (see Table 5). The number of applicants for the main intake increased until 2021, when the

Uni. Oulu intake	Credits Y1	Credits Y2	GPA Y1	GPA Y2
Main	43 (22)	36 (25)	3.7 (0.8)	3.6 (0.9)
DEFA	39 (15)	18 (18)	4.0 (0.7)	3.7 (1.2)

Table 6: Mean credits and GPAs by year of studies for the University of Oulu. Standard deviation in parentheses.

Uni. Jyväskylä intake	Credits Y1	Credits Y2	GPA Y1	GPA Y2
Main	40 (17)	39 (22)	3.3 (0.8)	3.3 (0.8)
DEFA	40 (14)	31 (20)	3.4 (0.6)	3.2 (0.7)

Table 7: Mean credits and GPAs by year of studies for the University of Jyväskylä. Standard deviation in parentheses.

Uni. Turku intake	Credits Y1	Credits Y2	GPA Y1	GPA Y2
Main	53 (22)	46 (23)	3.6 (0.8)	3.2 (0.8)
DEFA	51 (28)	42 (23)	3.4 (0.8)	2.9 (0.8)

Table 8: Mean credits and GPAs by year of studies for the University of Turku. Standard deviation in parentheses.

Uni. Helsinki intake	Credits Y1	Credits Y2	GPA Y1	GPA Y2
Main	44 (23)	42 (23)	4.1 (0.7)	3.9 (0.9)
Open uni.	42 (22)	39 (20)	3.8 (0.9)	3.7 (1.0)
DEFA	67 (17)	47 (26)	4.3 (0.5)	4.3 (0.6)

Table 9: Mean credits and GPAs by year of studies for the University of Helsinki. Standard deviation in parentheses.

intake seemed to reach its peak in popularity, at least for the time being.

The number of applicants for the open university and the DEFA intakes are the same, as they are reported as one, non-differentiated statistic. The beginning of the DEFA project increased the number of applicants from 31 to 161 for the open intake mechanisms combined. While the DEFA students only form a small portion of the students accepted through open intake mechanisms, it is likely that some of these students only heard of the possibility of open university studies because of the media attention the project gained. Since the open university intake and the DEFA intake share some of the course requirements, but the open university intake required fewer credits in total, it is also possible that some students tried the DEFA project and dropped out of the project at some point, opting for the open university intake instead.

4.2 Performance Between Intake Groups

4.2.1 University of Oulu. Based on the study records, the DEFA students gained fewer credits than the main intake students during their actual studies as a degree student in the University of Oulu. In the first year, the average is 39 credits for the DEFA students, and 43 credits for the main intake students (see Table 6). The courses that the DEFA students complete for admission are not included in the first year. For the second year, the difference seems even more drastic: 18 credits and 36 credits for the DEFA and main intakes, respectively. However, the number of DEFA students in the data set drops down to 14, which may overemphasize individual students' performance and personal situations. The differences in credits are not statistically significant for the first year ($U = 2273.0$ and $p = 0.07$), but they are for the second. For the second year, the Mann-Whitney test statistic $U = 561.5$ and $p = 0.003$, meaning that the main intake credits are statistically significantly higher than the DEFA intake credits.

From the GPA viewpoint, however, the DEFA students seem to get higher grades from their studies than the main intake students. For all the courses, their average grades were 4.0 whereas other students averaged 3.6. When inspecting yearly differences, the results were not statistically significant. For the first year, $U = 2398.0$ and $p = 0.13$, and for the second year, $U = 917.0$, $p = 0.25$.

4.2.2 University of Jyväskylä. During the first study year, students from both the main and the DEFA intake gained, on average, 40 credits with GPAs of 3.3 and 3.4, respectively. Average credits and GPAs remain rather similar during the second study year for the main intake students. Students from the DEFA intake gained fewer credits during the second year, on average 31, with a GPA of 3.2. All the credits and GPAs for the first two years are summarized in Table 7.

Statistically, there were no differences in the credits or GPAs between main and DEFA intakes for University B. For the first year credits, Mann-Whitney test statistic $U = 1086.5$ and $p = 0.42$, and for the first year GPAs $U = 1067.5$ and $p = 0.37$. For the second year credits $U = 791.0$ and $p = 0.11$, and for the GPAs $U = 935.0$ and $p = 0.41$.

Standard deviations of the credits are significantly large in both intakes for the first year, and the standard deviation values are further increasing in the second study year in both of the intakes.

4.2.3 University of Turku. While the accumulated credits for the main intake students and the DEFA students seem rather similar in Table 8, the DEFA students' first-year courses essentially consist of second-year courses. This is further discussed in Section 5.

Statistically, there were no differences in the credits or GPAs between main and DEFA intakes for the University of Turku. For the first year credits, Mann-Whitney test statistic $U = 1444.0$ and $p = 0.44$, and for the first year GPAs $U = 1360.0$ and $p = 0.36$. For the second year credits $U = 319.0$ and $p = 0.41$, and for the GPAs $U = 272.5$ and $p = 0.20$.

4.2.4 University of Helsinki. The credits and GPAs for each intake and year are summarized in Table 9, alongside the standard deviations (in parentheses).

When comparing the DEFA and the main intakes' credits for year one, Mann-Whitney test statistics $U = 7458.5$ and $p < 0.0001$, meaning that the DEFA intake credits were statistically significantly higher than main intake credits. For the credits of the second year, $U = 2460.0$ and $p = 0.26$, meaning that there is no statistical significance in the higher credits of the DEFA intake when compared to the main intake for the second year.

Uni. Oulu intake	Women	Men	Total
Main	57 (23 %)	192 (77 %)	249
DEFA	12 (52 %)	11 (48 %)	23

Table 10: Gender differences for each intake in the University of Oulu.

Uni. Jyväskylä intake	Women	Men	Total
Main	41 (34 %)	80 (66 %)	121
DEFA	2 (11 %)	17 (89 %)	19

Table 11: Gender differences for each intake in the University of Jyväskylä.

Uni. Turku intake	Women	Men	Total
Main	24 (25 %)	71 (75 %)	95
DEFA	6 (16 %)	32 (84 %)	38

Table 12: Gender differences for each intake in the University of Turku.

Uni. Helsinki intake	Women	Men	Total
Main	245 (28 %)	638 (72 %)	883
Open uni.	141 (34 %)	272 (66 %)	413
DEFA	12 (17 %)	58 (83 %)	70

Table 13: Gender differences for each intake in the University of Helsinki.

Comparing the DEFA and the main intakes' GPAs for year two, Mann-Whitney test statistics $U = 15509.0$ and $p = 0.19$, meaning that there is no statistical significance in the higher GPA of the DEFA intake when compared to the main intake in the first year. For the GPAs of the second year, $U = 2059.0$ and $p = 0.04$, meaning that the DEFA intake GPA was statistically significantly higher than the main intake GPA.

Between the DEFA intake and the open university intake for year one, Mann-Whitney test statistics $U = 1014.5$ and $p < 0.0001$, meaning that the DEFA intake credits were also statistically significantly higher than open university intake credits. For the second year, $U = 277.5$ and $p = 0.16$, meaning that there is no statistical significance in the higher credits of the DEFA intake when compared to the open university intake for the second year.

Comparing the GPAs between the DEFA intake and the open university intake, $U = 2311.5$ and $p = 0.0002$, meaning that the higher GPA for the DEFA intake is statistically significant for the first year. For the second year, $U = 207.5$ and $p = 0.01$, meaning that the higher GPA for the DEFA intake is also statistically significant for the second year.

4.3 Effect on Student Demographics

4.3.1 University of Oulu. In the University of Oulu, significantly more women were accepted through the DEFA intake (52 %) than the main intake (23 %), as seen in Table 10. This difference is statistically significant (Chi-squared test $p = 0.02$).

The average age is higher in the DEFA intake at an average of 29.0 years. For the main intake students, the average age at intake is 23.3. The Mann-Whitney test statistic $U = 1297.5$ and $p < 0.0001$, meaning that the difference is statistically significant. The standard deviation for ages in the DEFA intake is 7.1, and for the main intake, 5.4.

The age distribution is bimodal for the DEFA intake with gentle peaks at 22 and 36 years (Figure 1, University of Oulu). For the main intake students, there is a remarkably high peak at 20 years with a long tail in the age distribution.

4.3.2 University of Jyväskylä. When studying genders of different intakes in the University of Jyväskylä, most of the accepted students are men. Only 34 % of students in the main intake are women, and the proportion of women decreases even further in the DEFA intake, being just 11 % (Table 11). This difference is statistically significant (Chi-squared test $p = 0.04$).

The average age of the accepted students in the DEFA intake is a little bit higher, 26.1, than students in the main intake, 24.3 ($U = 1536.0$ and $p = 0.02$, meaning that the difference is statistically significant). The standard deviation in the main intake is 5.6, and in the DEFA intake 4.4.

The age distribution is bimodal, especially for the DEFA intake, with peaks at ages 22 and 28 (Figure 1, University of Jyväskylä), although the total number of students is relatively small. For the main intake, there is a clear peak at ages 20 and 21. Both intakes have a long tail in the age distribution, continuing up to age 38 in the DEFA intake and to age 45 in the main intake.

4.3.3 University of Turku. The gender balance is somewhat similar in both intakes at the University of Turku, as seen in Table 12. The overall balance is biased towards male applicants, as is typical for the field: 16 % of the accepted students from the DEFA intake are women, and 25 % from the main intake. The difference is not statistically significant (Chi-squared test $p = 0.24$)

The average age is much higher in the DEFA intake, and the difference to the main intake average age is statistically significant ($U = 3054.0$ and $p < 0.0001$). There is a high peak in the number of students at ages 19 and 20 for the main intake students, whereas the DEFA students are more scattered and do not form visible peaks (Figure 1, University of Turku). The standard deviation for the main intake students is 4.3, and for the DEFA students 6.5.

4.3.4 University of Helsinki. For the University of Helsinki, the open university intake clearly had the most women at 34 % of the accepted students. The main intake has 28 % women, while the DEFA intake scores the lowest at 17 % (Table 13). These differences are statistically significant (Chi-squared test $p = 0.004$).

The average age for the DEFA intake and the open university intake was very similar at 31.7 and 31.5, respectively. The main intake students were younger on average at 26.8 years. The standard deviations were 9.6 for the DEFA intake, 8.0 for the open university intake, and 7.4 for the main intake. The difference in average ages between the main intake and the DEFA intake is statistically significant ($U = 21456.5$, $p < 0.0001$), while the difference between the open university intake and the DEFA intake is not ($U = 14287.0$, $p = 0.44$).

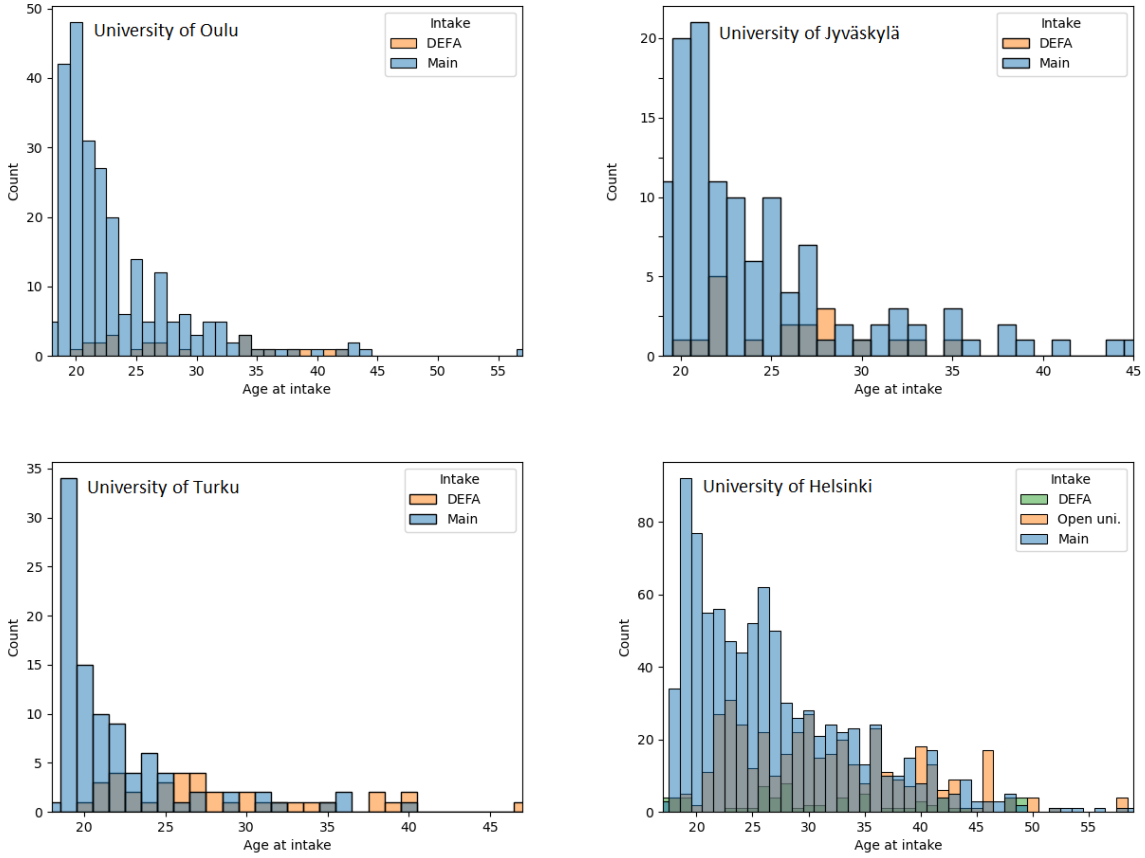

Figure 1: Distributions of students' ages at intake for each university.

The DEFA intake's age distribution has peaks around 26-28, and at 35 (Figure 1, University of Helsinki). The open university intake has no clear peaks, and the students from this intake are somewhat evenly distributed regarding age. The main intake has a clear peak at 19 (students entering immediately after high school), and a smaller peak around 26, with a long tail until 60.

5 DISCUSSION

While building MOOCs, and even smaller-scale online courses, takes resources, after the initial workload, the courses typically become easier to manage, especially if they utilize a wide range of automated exercises, as is typical in computer science courses. The switch to more scalable online courses seems to pay off in the long run if they are used for student intake, considering the costs of arranging physical entrance exams. Arranging physical entrance exams each year consumes a variety of resources, even if the vast majority of the applicants are not accepted into the program. When using completed courses as an intake mechanism, even if students decide that they will not apply for the university, they have still gained credits and knowledge that they can potentially use in another degree, or in their working life.

While the open intake mechanisms have gained popularity in all of the participating universities, many of the younger applicants still gravitate towards the traditional main intake, entering the university either with their high school grades or entrance exam. The main intake is possibly seen as the "normal" intake mechanism, which might be more familiar to both high school students and high school study counselors. The age distributions in Figure 1 show that the students accepted through the DEFA intake tend to be slightly older, or in some cases, already in typical working age. The flexibility and practicality the DEFA intake offers may be more attractive for applicants with different working or family situations than those who have just graduated from high school.

The credits completed with the open university or DEFA courses are not included in the results for the universities of Oulu, Jyväskylä, Turku, and the open university intake of the University of Helsinki. This can skew the results in two major ways. The courses are usually scheduled for full academic years, while the students from the aforementioned intake have completed approximately half of academic year's worth of courses. This can cause issues with scheduling, on the curriculum-level, as well as on a personal level. Arranging and completing courses out of the regular schedule may require more

self-regulation from the student. Also, since students are completing at least partially courses from the second year, the credits they have acquired for the year labeled as the first year in this study may be from more advanced courses, while the main intake students start from the basic courses.

In almost all of the universities, the DEFA intake's gender balance is even more skewed than in the main intake, with relatively more men accepted. The only outlier is the University of Oulu, in which 52 % of the students from the DEFA intake were women. Further studies are needed to make any conclusions on gender distributions, such as 1) comparing the gender distribution of students who started to study DEFA courses, but dropped out, and the gender distribution of students who completed the courses, 2) comparing motives of students: is the motive to attend the courses to achieve general knowledge of ICT topics, improve e.g. programming skills, or applying to the university, and 3) finding out other factors which could explain differences between genders and intakes, for example, computing as an existing hobby or need for social support during courses.

Courses completed for the DEFA intake are a good way to clarify whether the field of ICT is what an applicant wants to pursue. Trying out open courses can also spark an interest in a student who did not necessarily consider applying for a computer science program beforehand. This is especially important as computer science and programming are not widely taught in primary or secondary education in Finland, which means that applicants may have incorrect preconceptions of the field, for better or worse.

In all our reported cases, students completed fewer credits during their second year of studies, even if the differences are not necessarily statistically significant. As there is a shortage of computer science professionals in the Finnish job market, it is possible that some of the students are either getting or returning into working life – well-performing students can get hired as early as during the summer of their first year of studies. If the cohorts from different intake mechanisms were observed for a longer period of time, this transition to employment may be clearer even from the course completion data.

Nationally, there have been efforts to make students begin their studies earlier, for example, immediately after graduating from high school without any gap years. The DEFA project has been one experiment to pursue this goal. In the light of the results of this study, however, it seems that the DEFA provides more opportunities for those who want to change their career later in their life. For the intended target group, high school students, there have been indicators that they are not able to fit university courses into their already busy timetables. Thus, the number of young students has not significantly increased with this selection method. Still, the DEFA project and other related efforts have made the open online courses more known and popular, which is seen to benefit student recruitment in general and provide a good basis for further development.

In the University of Oulu, the general impression of the handful of degree students selected based on their earlier open university studies before 2019 intake has been very positive. They were seen as motivated and capable because they, for example, were already familiar with the field. From this viewpoint, it has been a surprise that the students accepted through the DEFA intake have performed worse than other students during the last three years. One explanation may be that they have already passed some first-year courses and cannot find suitable second-year courses to fill the empty slots in their timetable. However, the age distribution of the accepted DEFA students and the dropping number of credits for the second study year suggest that these students are already working, and may also have established family life, leaving less time for studies.

The results with the most statistically significant comparisons were with the University of Helsinki DEFA intake, which was built quite differently from the other DEFA intakes. The University of Helsinki open university intake and other participating universities' DEFA intakes indicate that the intake mechanism works – the accepted students perform at least as well as the students from more traditional intake mechanisms. Additionally, it does seem, that completing a full year of studies independently does bring in a completely new and different cohort of students.

5.1 Limitations

The results of this study are specific to this particular context. There are study structure and country-specific factors, such as student benefits and government funding models, and one cannot draw direct conclusions to other contexts based on our results. Additionally, this study only inspects computer science programs, in which online courses are common and well-developed. In many fields, it is possible that arranging online courses at this scale would not be possible due to, for example, mandatory laboratory courses.

The DEFA project has been running only for a few years, and thus, the collected data is still limited. This study only strives to examine some preliminary results. Longer-term effects, such as the intake's effect on graduation times, are still unknown and part of our future research endeavors. Additionally, this study only inspects quantitative data and does not take into account the qualitative side of research, for example, how students perceive the different intake mechanisms. Lastly, the data that was available for this study reported students' genders in a binary, man-woman format, which hides any gender minorities from our results.

6 CONCLUSIONS

In this paper, we investigated an extended, MOOC-based university intake mechanism and its effects in four universities. The purpose of this new intake mechanism was to reach potential student populations who would not have considered computer science as their major otherwise, and to scale the university intake for the growing number of applicants.

Our research questions and their answers are as follows:

RQ1. How did the DEFA project affect student intake in general?
Answer: The DEFA intake increased the number of applicants in all of the participating universities, and the number of accepted students in almost all, though there were some yearly differences, or capped student intakes due to university-set intake quotas.

RQ2. How do students accepted through the DEFA project perform in their studies compared to students accepted through other intake mechanisms?

Answer: Generally, students accepted through the DEFA intake seem to perform as well as students from other intakes, and in some cases, better both in accumulated credits and GPAs.

RQ3. Do the demographics of students accepted through the DEFA differ from the general student population?

Answer: With the exception of one university, the gender balance of the DEFA intake is even more skewed than the gender balances of other intake mechanisms with even more men accepted compared to women. The DEFA students are, on average, older than students from other intakes.

According to our study, the new intake mechanism has a positive correlation with student performance. In the introduction, we also discussed how important it is financially both to students and to education providers for students to graduate within the target time. However, at this point, it is too early to evaluate that and we leave it for future work.

As for other future work, we would like to inspect students' performance in more detail: for example, how many of the students who start the DEFA courses finish and actually apply for a study right? How many drop out during the first course, and why? And more importantly, are there potential interventions or changes to the course that could increase retention of students?

The students accepted through the DEFA intake were clearly older on average than the main intake students. We would be interested in either modifying the open intake mechanisms so that they gain more interest from younger applicants, or building new intake mechanisms that clearly target high school students, for example, by emphasizing the cooperation between universities and high schools directly.

We also have an interest in further studying women and other traditionally underrepresented groups in computer science programs, and how to both attract and retain these demographics. One approach would be reaching these demographics through interview-based research. As concrete changes, we could inspect the content of our course materials – for example, a recent study [13] noted that women tend to show more interest in problems that are expressed through real-life issues. High school cooperation and a related intake mechanism could also provide some assistance in reaching underrepresented groups earlier and more directly.

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