Is Knowledge of Mathematics a Key for Success for Studying ICT?

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Abstract. Most technical studies require and assume from the students a certain knowledge of mathematics. In this paper an experiment is described where students, starting with a study of ICT at a bachelor level, are performing a very short test in mathematics to measure their knowledge. The results of this test are compared with the results students are having with the real exams at the end of the first quarter of the first year.

Keywords: predictive testing, course development, mathematics
Key Terms TeachingMethodology, ICTEnvironment, TeachingProcess

1 Introduction

At the institute of ICT at the HU Utrecht University of Applied Sciences around 500 students start with a study in ICT with the aim to get a bachelor degree. To start this study, students should have a certain level of education. The students starting at our institute of ICT have a mixed background. Actually two types of students can be distinguished: students with an education that has its focus on working in practice and also has its focus on a certain specialisation and students with a more theoretical background that are supposed to specialise themselves later at a university or higher education. Because of this mixed population of students, the background in mathematics is quite different.

For all starting students a small mathematics test has been developed. One of the goals of the mathematics test was to get a feeling of the level of math education of our new students. This would give us a clue what additional courses and help we should offer the students of different types.

Apart from that primary goal, it would be interesting to see if the result of the mathematics test predicts the success of the students with their first exams. This is what this paper is about. The research question that will be the focus of this paper is: is there a correlation with the results of the exams and the math test?

This paper is organised as follows: First related work will be discussed. Next a section will be presented explaining the test setup, followed by a section containing a short description of the courses in the first quarter. The section "Results"

is dedicated to the evaluation of the results of the exams of the first three courses in regards to the mathematics test. In the section "Discussion" some important remarks will be given about the results found so far. Finally a conclusion and a bibliography will end the paper.

2 Related Work

Testing students and test design is the subject of many publications and scientific research. An example of a publication where the same type of testing has been used is [3]. It describes the Philadelphia Public Schools' formative testing program, used to diagnose students' difficulties under mastery learning, especially in mathematics. It also explains the concept of formative testing. This type of testing is used to give students only feedback on the level of knowledge or understanding they are at, but not to let a student pass or fail. In our situation, the mathematics test was formative, while the exams were not formative.

In [2] a study is presented that examines the extent to which student engagement is associated with experimental and traditional measures of academic performance. A publication about modern testing methods is given by [4] in "Assessing and Promoting Student Learning: Blurring the Line Between Teaching and Testing". This publication shows that testing should not only be meant for checking the level of the student, but can also be used to give feedback to the student as well as to the educational institute. This supports our view that the type of testing that has been used is important and useful.

3 Test Setup

The main goal was to discover the level of math education the students had received. We do not measure the skills, but the knowledge of several mathematical issues. This is done by setting up a list of problems that are easy to solve if the student has had an explanation of the mathematical concept in the past.

3.1 Problems to be Solved

In the test a set of problems were presented to the students. Not much work had to be done to solve the problems. There is a certain increase of complexity of the problems. An explanation why this problem was added to the list is given for every problem. This explanation was not presented to the students performing the test.

1. Calculate
$$2 + 3(5 - 2) =$$
This is just a simple start with a numerical calculation that should be explained already at the primary school

2. Solve x in:
$$2x - 7 = 3$$
Can the student solve a linear equation
3. Solve x in:
$$(x - 2)(x + 3) = 0$$
Can the student solve a quadratic equation? The question is stated in a form that the solutions should be clear without using the solution for the general so-called a b c formula ($ax^2 + bx + c = 0$)
4. Given $f(x) = x - 7$. Calculate:
$$f(2) =$$
Is the student aware of the concept of a function?
5. Calculate:
$$3^3 =$$
Does the student know how to handle powers?
6. Calculate:
$$2^2.2^3 =$$
Is the student aware of the fact that exponents should be summed in the given case? Even if the student does not know this, the solution can be calculated
7. Simplify:
$$a^b.a^c =$$
Is the student aware of the fact that exponents should be summed in the given case? Here there is now escape as in the previous example
8. Calculate:
$$^{10}log(1000) =$$
Does the student know what a logarithm is?
9. Calculate:
$$2.cos(\pi) =$$
Is the student capable to use goniometric functions and radians?
10. Calculate:
$$\sum_{n=1}^{3} n =$$
Does the student know what the summation notation means?
11. What is the first derivative of $f(x) = 2x^3$
The first derivative is: ...
Is the concept of derivative of the calculus known by the student
12. Calculate:
$$\int_1^3 x^2 dx =$$
Does the student know how to integrate a function?

3.2 Test Condition

Before starting the test, students were told that this test was only meant for information. The results would not influence a decision to let the students pass or not. The information could be used by the student to discover which field of mathematics he/she should work on or what supporting courses he/she has to attend to get the presumed level in mathematics.

The test takes only 20 minutes of time and is performed by using the web-based Socrative environment [8]. The reason to use Socrative was based on the fact that it is freely available, had the requirements needed for our test and is easy to use. Another advantage was the fact that the results were available in a mix of formats including a spreadsheet. There are also other possibilities like [6] and many others to run the test and other institutes might use their own preferred test environment.

4 The Courses of the First Quarter

To give the students the possibility to orient on the possibilities in a later phase of the bachelor program, all three courses in the first quarter should more or less be tied to the final four tracks the student has to select during the first half year [7]. The three courses are:

1. ICT in organisations. This course explains the roles ICT can play in real business situations.
2. Programming. An introductory course in programming is given based on the popular language Python.
3. Computer systems and networks. In this course students learn the basics of computer science and also the way internet works.

One of the reasons why these three courses are presented in the first block of the study is that it is a nice way to demonstrate the layered structure that plays an important role in many ICT concepts [9]. At the top is ICT in organisations, The middle layer is presented by programming and finally the bottom layer (hardware, operating systems and networking) is covered by computer systems and networks. Having a test in mathematics and three courses to start with, we will present the results of our research in the next section.

5 Results

To answer our research question, the correlation between the exam results and the math test results should be calculated. For the correlation the well known formula for the correlation coefficient r has been used [1].

$$r = \frac{\sum_{i=1}^{n}((x_i - \overline{x})(y_i - \overline{y}))}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 \sum_{i=1}^{n}(y_i - \overline{y})^2}}$$

In Table 1 the results for the correlation of the outcomes from the math test and the results of the fist examination of the three courses are given. N is the number of students that made the math test. So the answer to the research question pre-

Table 1. Results

Course	N	Correlation r
IT in organisations	225	0.05
Programming	225	0.25
Computer systems & networks	225	0.06

sented in the introduction should be: "There is only a small correlation between the results of the exam in programming and the results of the math test. The other two courses have only a very small positive correlation."

The next question that arises is: is there a correlation between the results of the courses given? To investigate this, three correlations were calculated. One for each combination of two courses. In this case the number of students N involved is again 225 as in the previous result. In this case (see table 2) the correlation is

Table 2. Results

Course	Course	Correlation r
IT in organisations	Programming	0.53
Computer systems & networks	Programming	0.56
Computer systems & networks	IT in organisations	0.58

much more evident, showing that students who perform good at one exam also had a good result at the other exams and the other way around for students performing not so good.

6 Discussion

At the start of this research we expected a positive correlation between the level of knowledge of mathematics and the results of the exams for the first quarter. This was based on the fact that in the course Computer systems and networks the binary system is explained where the use of exponents is inevitable. To our surprise some students did not know anything about use of exponents and the mathematical properties of it. For these students the subject might be hard. The same was true for programming where we expected the notion of a function to be necessary. However, it turned out that the math test cannot be considered as

a predictive instrument of how a student will perform. It should be mentioned, as was already done in section 3, that the test does not check the math skills but only the awareness of certain concepts in mathematics has been checked.

The primary goal for which the test has been developed was to see with what level in mathematics the students start at our institute. Though not a subject of this paper it should be mentioned that it turned out to be very helpful to know what extra courses in mathematics were needed during the bachelor phase. As was expected, the diversity in background knowledge with respect to mathematics turned out to be huge.

7 Conclusion and Future Work

As shown is this paper, the level of knowledge of mathematics does not play an important role in the first part of our bachelor program. However, in later part there are specialisations that rely more heavily on mathematics, so it would be interesting to see if there is a connection between the mathematical background of the student and the specialisation he/she will choose. The research presented in this paper is only a start and later investigations and research should be done to see if the test is predictive in other aspects. Because we have different types of students entering our bachelor program, it is interesting to see what these students will actually choose as their specialisation and also how they perform in other courses that might be more based on mathematical insight. A study on other types of predictive testing like in [5] might also be interesting.

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