Does student profiling help course arrangements?

P. Porras
Principal Lecturer
Saimaa University of Applied Sciences
Lappeenranta, Finland
E-mail: paivi.porras@saimia.fi

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INTRODUCTION

Universities of applied sciences (UAS) in Finland receive funds primarily from the Ministry of Education and Culture. One key issue in budgetary appropriation is the number of students graduating from the institution. Especially in engineering, the problem is dropouts. During the first year or just after it, many students drop their engineering studies and, unfortunately, these students seem to also have struggled in their mathematics courses.

Young people under 25 are obligated to apply for a study place in Finland if they are out of work. Without applying for a study place, they have no rights to allowances paid by society. This may partly explain the lack of motivation in beginning students and the resultant dropout rate. On the other hand, some of the struggling students have already been working in their chosen field, so motivation should not be the problem. This article studies the profiles of beginning students in mathematics and how these profiles might be factored into the course arrangements, so that more students would graduate.

The educational backgrounds of engineering students at universities of applied sciences include those from both vocational colleges and high schools. Some of them have studied only a little math after elementary school, while others would qualify for a degree programme in mathematics. Normally, the progress of university students is observed in the final exam meaning that a student may have been struggling for several weeks or even months before notified by a lecturer. Although the lecturer would give the extra help at that time, the student may already have dropped out. The idea of profiling the students at the beginning of their studies is that extra help could be provided during the course to the motivated weaker students. Because of time resources this help cannot usually be provided to all students.

For that reason, beginning students were asked to participate in a proficiency test to reveal their actual calculation skills [1, 2]. During 2010 and 2011, new students at Saimaa UAS, Finland, filled in the surveys about motivational and self-regulating aspects of learning. Combining the two data of 2010 and 2011, appropriate information was found and profiles were formed. These profiles were used with the beginning students of 2012.

1 PROGRESS IN MATHEMATICS

As described previously, students from academic years 2010 and 2011 filled in the surveys about motivation and self-regulation. The motivation questionnaire consisted of 15 questions with four alternatives in each question. Those 60 alternatives altogether handle all learning motivation groups presented by Kauppila [3]: *avoidance motivation, diverged motivation, escape motivation, achievement (or performance) motivation* and *intrinsic motivation*. Students were asked to give 1, 2 or 3 points for alternatives in each question. The highest points should be given to the alternative best describing the student, the second highest to the next one etc. They did not need to use all points but at least one point must be given in every question. Inside the question, the points could not be given twice. At least one alternative was left empty in every question. This kind of ordering for alternatives was used to know which of the alternatives motivated students most.

The questionnaire about self-regulation was structured according to Pintrich [4, 5]. There are 12 questions with four alternatives in each question. Contrary to the motivation questionnaire, students were asked to use five-level Likert scale in self-regulation questionnaire. One point referred that *it does not describe me at all* or *I hardly ever feel like this*. Five points referred *it describes me* or *I feel like this almost all the time.*

These answers, students' background information like previous education, mathematics studied in a high school as well as results on the proficiency test were used for analysing progress in mathematics based on grades. Students did not answer the surveys anonymously, so their grades in math courses could be included to the data. Analyses are mainly done with Decision Tree in IBM SPSS, as it shows which questions in surveys highlight features the best. IBM SPSS also enables syntax programming. When a new significant feature was found, it was included to a variable called *student type* to classify students. Little by little students were categorised into four types:

1. Students at risk (great difficulties in passing the math courses)
2. Weak students (low grades)
3. Average students (no difficulties in passing)
4. Excellent students (high grades)

For example, it could be seen that students giving more than one point to the choice "*I probably do not need supervising in mathematics as it has always been easy to me"* are passing the courses with good grades. On the other hand, giving at most one point to that sentence and the highest points to the sentence "I have to work to pass the courses" refer to the struggling student. Both these sentences describe self-esteem, and the weaker students seem to have significantly weaker self-esteem. It has been shown that students' expectation of their own learning has a great impact on performance [6, 7]. This suggests that elevating weaker students' self-esteem may positively affect in their progress.

One surprising sentence was "*When studying the math courses, I look for extra material from the Internet or a library if needed".* This sentence was originally meant for finding self-regulated students. However, high points here combined with weak results in the proficiency test is suggesting that the student is struggling with math. According to Clarebout et.al. [8], no evidence is found that weaker students even benefit from the use of support devices such as e-learning materials. It would be interesting to know whether these students are not capable of recognizing good material or they do not understand the material they are reading.

Results of analysis were compressed to sixteen profiles [2]. The number of profiles is quite high and it may be decreased after further analysis. Remember that the profiles should describe also the average students, as not all students are excellent, or struggling in their studies. During the academic year 2011-2012, there was also included the last choice "*None above describes me"*. This choice was selected by the students, who failed their first course in math. Does it infer that some weak students do not even recognize their customs and thoughts during the studies?

One interesting profile was "*I want to graduate as fast as possible, so I find out a lecturer's requirements and custom."* Although the profile seems to be encouraging and self-regulated, it was selected mainly by weaker students. It seems that these students selected engineering based on status. Students are not ready to work to gain the good grades, but they are doing lot of work to avoid actual studying. More detailed information in surveys and results of motivation and self-regulation as well as profiling may be found in [1, 2].

2 INTRODUCTION INTO MATHEMATICS

2.1 Basic information on the course

Students for this course are selected by the proficiency test. Because of the wide range in math skills, students participated in the proficiency test at the beginning of studies. If a student got at least 90% of the maximum points in the proficiency test, the student did not need to take the course. All the others were directed to the course.

All main topics of basic calculation are gone through during the course. This includes everything from basic arithmetic calculation and handling expressions to solving polynomial equations. All the topics should be understood before entering the engineering studies but, for one reason or another, they are not.

As the topics are so essential for all mathematics, students are required to answer all test questions correctly. There are several smaller tests during the course, where students can show their skills. If the student makes a mistake on the test, the test may be taken again on the failed part. Failing a test did not prevent attending the next test.

2.2 Background information on students

According to *Table 1*, the number of high school students in both programs is significantly higher than the number of students from vocational colleges. As the high school students are considered to be better in theoretical subjects, these students should not have big problems in math courses. Furthermore, the proportion of students with extended math in program “K” is higher than in program “R”. Students with extended math should not have any difficulties in their first year math studies, so passing the math courses should not be a problem in program K.

Table 1. Basic information on students

	Program K	Program R
High school	80.0%	71.4%
- extended math	56.0 %	34.7%
- normal math	24.0 %	36.7%
Vocational college	20.0 %	28.6%

When students were profiled based on their results in the proficiency test and suspected student type, the progress does not look so obvious anymore. As seen in *Table 2*, over half of students in program K were classified to be at risk (the ones struggling) and 16% of the students to be weak. Thus, almost 70% of these students are assumed to have difficulties in their math studies. Although the numbers are by no means good in program R, the predicted progress does not differ from high school background so much. Further analysis showed that over one fifth of students with extensive math in program K were classified to be at risk whereas in program R it was only about 10%.

*Table 2.*Predicted progress

	Program K	Program R	Total
at risk	52.0%	40.8%	44.6%
weak	16.0%	20.4%	18.9%
average	12.0%	18.4%	16.2%
excellent	20.0%	20.4%	20.3%

2.3 Course arrangements

The course *Introduction into Mathematics* was traditionally lectured separately in programs with same amount of lectures. This year it was decided to separate it according to student types and results in the proficiency test. The group called *A* consisted of the weakest students. These students had major problems in their calculation skills. The group called *B* did not have excellent results but they were assumed to benefit from revision in basic calculation. For this reason, one third of their lectures were allocated to the group *A*. All excellent students with good results in the proficiency test were exempted from this course.

Both groups had their own lectures meaning that lectures were planned independently. However, topics on a weekly basis were decided in advance as topic tests every other week were the same. The same topic tests were used, as it made comparison of progress possible.

Lectures of the group *B* followed the lecturer's traditional way of teaching. These students got the lecture on the topic with examples and solved most of the exercises after the lectures. Unfortunately, the lecturer had to cancel several lectures because of meetings.

The lectures of the group *A* were totally redeveloped. It was thought that if these students did not benefit from the traditional teaching in their previous education, the method would not be any better for current studies. It must be noted that this lecturer also had more lecturing time for every topic. These students should reach the calculation skills needed in engineering in a very short time.

Instead of the topic being lectured, all topics were started by thinking about it together. Not all students had even studied some topics and some of these students had enormous deficits in calculation skills, so it was very important to relate topics to pre-known basic calculation instead of just writing the formula on the board. For example, writing $\frac{x}{2}$ in the form $\frac{1}{2}x$ was not understood. This was explained as "*If a banana is bisected, then one gets half of the banana".* At this level, it would have been waste of time to derive the formulae in theory only.

During the discussion section, students related the topic to their pre-knowledge from the previous education and previous lectures and tried to find new solution methods. The lecturer only started the lecture with a problem and led the discussion by giving some hints or by asking questions.

After the "lecturing", students got their exercises. The main idea was that students could solve all exercises during the lectures. As mentioned earlier, these students were very weak in their math skills, so the lecturer wanted to keep abreast of progress. This kind of teaching also enabled correction of mistakes in notations before they became automatic. If many students struggled with the same problem, it was solved on the board together with the discussion method; the lecturer was a secretary and the students told what should be written. The lecturer wrote also the notation mistakes expecting that somebody would remark on it. The lecturer had to correct the mistakes without prompting from the students only a few times.

Part of the exercises were changed from traditional *solve the problem* or *simplify* kinds of problems. As found in literature [9, 10], writing, e.g. essays, in mathematics helps in deepening understanding. The method, called *languaging,* compels a person to understand the topic as it must be explained on paper. These students were not asked to write essays but to explain the solution method. Without the languaging, students may have only dipped into the calculation and tried to copy the method in upcoming exercises without thinking. With this problem they were forced to explain to themselves *why* a particular step is done.

In some problems, the solution included common mistakes. Students were asked to find the mistakes and also solve the problem without them. All mistakes were usually found easily by students. The catch in this problem was that when solving the traditional exercises, students may have made exactly the same mistakes. The light on a student's face at the moment of realization that the same mistake had been corrected just five minutes ago, revealed the learning.

2.4 Feedback from the course

The feedback in the group *A* was great. Students liked the pace during the lectures and that the help was always available. One student wrote that "*Lectures were easy to follow and even me, who have never before studied these topics, could understand and learn them. Do not change anything in the course arrangements*".

Students also liked the small topic tests. According to them, it gave them motivation to study as the number of topics was not too big to handle. With small topic tests, students became alerted quickly if they had misunderstandings in the topic.

Although the overall feedback was excellent, there is still room for improvements. Students did not receive the correct answers, but the problems were always solved on the board. Answers were not given to prevent misbehaviour: some students check the answer first and then start to think how it was obtained. In real-life engineering, this kind of method does not work. However, the missing answers hinder studying at home.

The relaxed atmosphere during the lectures was a complex issue. Students easily approached the lecturer and asked for help. They also discussed the exercises in small groups. Overall, students were active in learning. At the same time, some students suffered from the noise. Some kind of balance must be found in the future.

3 INFLUENCE ON PROGRESS OF MATH STUDIES

Results of the introduction course are promising. As shown in *Table 3*, only four students from the group *A* failed the course.

*Table 3.*Results of the introduction course

	failed	total
A	4	28
B	1	29

All failed students are studying in the program R. At least in the group *A* these failed students were "craftsmen" who are not familiar with expressions. For them, mathematics has been arithmetic calculus.

As the results and background of students from program K were so promising, the expectations for the first professional math course were high. However, forty per cent of the students failed the course. In program R, the proportion of the failed students was only 12.5 per cent. There are many reasons for this terrible result, and it can never be explained thoroughly. The teacher of the group A lectured the first professional math course in the program K and the teacher of the group B lectured in the program R. Content of the courses is basically the same but, of course, different topics of the special interests in the field were highlighted. Both lecturers had done well with the introduction course. However, some kind of reflection about the teaching is needed.

The lecturer A had worked at the university level for ten years before teaching at Saimaa UAS, whereas the lecturer B had previously worked at the high school level. Perhaps the demands of the lecturer A for passing the course were too high. Although the lecturers may have influenced the passing with their demands, it cannot be the only reason. When the introduction course was given, the group A had 8 lectures in a week and the group B had 4 lectures in a week. At the same time both groups were studying 3 lectures a week for the first math course as well, along with all the other courses. The demand of “no mistakes” for passing the introduction course may have caused great pressure for the students. When the course ended, they just broke down and could not concentrate on math anymore.

The lecturer A did not have so much time for teaching the first math course as for the introduction course. There was no time to reform the exercises taking the languaging into account, nor was there time to check all exercises. As a result, the lecturer A reverted to old habits in teaching, though knowing that the new way had brought promising results.

The students of program K start their first year project at the same time when the introduction course ends. In their project, they have to design and manufacture a man-powered vehicle with three wheels. At the end of the academic year 2012 – 2013, they have a time trial where the best vehicle is selected. This project takes considerable time and effort. Because students find it interesting, they take the time from not so interesting topics, e.g. mathematic, and the tailspin begins.

4 SUMMARY

Without doubt, profiling the students gives more information and helps out course arrangements. It revealed the students who should be tutored more thoroughly. If student’s self-esteem in mathematics can be improved, skills do improve. In the long run, this produces more graduates and decreases frustration felt by students.

Languaging gave promising results during the introduction. However, rewriting all or even some exercises in this form requires time that is not readily available to the lecturer. Hopefully, languaging will come into common use with time. Also, starting the new topic by refreshing previous knowledge of the subject should help students in understanding. This could be seen in the introduction course with weaker students. At this point, it is very important that the lecturer speaks the same language as students. The examples must be easy to understand for all students.

Although re-organizing the lectures from traditional lecturing to discussion-based format requires time and effort, it is worth it. Obviously, attempting to address all learning styles during classes, also in mathematics, promotes understanding. At least in Saimaa UAS, this method will continue and be developed further in mathematics.

There are many studies of motivation and self-regulation in mathematics. According to the studies, the more motivated and/or self-regulated students are, the better grades they are achieving. However, the highly-motivated student may lose the interest if mathematical background is weak and no help and/or encouragement is available. Recognizing the weaker but motivated students and encouraging these students may be even more important than just recognizing the motivated and self-regulated students.

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