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Evaluating admission procedures for teacher education in Finland

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Abstract. In Finland the number of applicants for elementary teacher education is many times greater than the number of accepted persons. In this article we focus on the significance of the entrance examination procedures at three Finnish universities. Our findings imply that the differing admission procedures at the institutions yielded different student profiles. The test component “mathematics-science” used on the entrance examination in Turku was found to be a significant separating factor, but also the applicants’ mathematics achievement in upper secondary school seems to be an applicable criterion for developing admission procedures.

Key words and phrases: teacher education, pre-service teacher, admission criteria, proficiency in mathematics.

ZDM Subject Classification: B50, D10, D30, D60.

Introduction

According to the PISA study, Finnish comprehensive school students’ performances in mathematics and science are of a very high level. The explanation for this success can be a combination of several factors [1]. It seems that teachers play a central role in Finnish PISA success. In Finland, unlike in many other countries, the number of applicants for elementary teacher education is many times larger than the number of accepted persons, and the students admitted have generally succeeded well on many upper secondary school subjects. According to PISA, in Finland comprehensive school students' attitudes towards mathematics are, however, among the lowest in Europe.

In Finland there is an annual conference considering the development of admission process for teacher education. The prevailing perspective in Finland has been that there is no need to emphasize mathematics in the enrolment procedures. This view implicitly assumes that regardless the mathematical background and competence of the elementary teacher student she or he can become a good mathematics teacher. However, the results of prior research show that in Finland many pre-service elementary teachers' proficiency in mathematics is not good enough in the beginning of their studies from the viewpoint of their future career [2].

In order to emphasize mathematical competencies in the admission procedure, it is possible to give credit for applicants according to their achievement in the mathematics examination of the national Matriculation Examinations (ME). This approach can be criticized for focusing on mathematical content (e.g. algebra and calculus) that is not very relevant to elementary education. In order to measure more accurately such competencies that are central to elementary mathematics teachers, it seems to be useful to design a specific mathematics test for the admission examinations.

This study is a part of the research project "Elementary teachers' mathematics: Development of mathematical thinking of elementary teachers students in their studies" (project # 8201695), which is financed by the Academy of Finland. (Here elementary teacher education means teachers teaching in 1–6 grades.) As one aspect of this project, we looked at the level of mathematical competence of students from the Universities of Turku, Helsinki and Lapland who had entered through four different admission procedures.

Teacher students' proficiency in mathematics

We see, as Shulman, that the central parts of teacher competencies are (general) pedagogical knowledge, content knowledge and pedagogical content knowledge [3]. In Finland teacher education gives versatile competence in general pedagogical knowledge. Teachers' professional development, the emphasis on reflection and teacher empowerment has become central topics in Finnish teacher education [4]. Every teacher student completes a master thesis in educational science. This kind of scientific education distinguishes Finland from many other countries.

In this article we are focusing on the mathematical content knowledge of the elementary education teacher students. By applying [3], mathematical content knowledge is knowledge about mathematics and its structure. It refers to the amount and organization of mathematical knowledge per se in the mind of a teacher. Mathematical proficiency can be defined as procedural knowledge and conceptual understanding [5, 6]. Here we use the following more detailed classification adopted by [7, p. 106]:

"The five strands of mathematical proficiency are (a) *conceptual understanding*, which refers to the student's comprehension of mathematical concepts, operations, and relations; (b) *procedural fluency*, or the student's skill in carrying out mathematical procedures flexibly, accurately, efficiently, and appropriately; (c) *strategic competence*, the student's ability to formulate, represent, and solve mathematical problems; (d) *adaptive reasoning*, the capacity for logical thought and for reflection on, explanation of, and justification of mathematical arguments; and (e) *productive disposition*, which includes the student's habitual inclination to see mathematics as a sensible, useful, and worthwhile subject to be learned, coupled with a belief in the value of diligent work and in one's own efficacy as a doer of mathematics."

According to earlier studies, there are some important topics in the elementary mathematics curriculum that many elementary teacher students find hard to master. This becomes even more apparent when we look beyond computational skills, and expect teachers to understand the fundamental concepts properly. The challenging topics to understand and to teach are e.g. division [8, 9] and rational numbers [10, 11]. Mathematical reasoning based on the logic of natural numbers seems to be very resilient, and the changes that are required in order to use fractions and decimals are demanding. Rational numbers call for a different kind of thinking that has not received adequate attention in the schools. [10] This difficulty indicates that transition from whole numbers to rational numbers requires a conceptual change that is hard for many student teachers [12].

Focus of the paper

Here, we focus on the significance of the entrance examination procedures for the initial mathematics proficiency of students admitted to the elementary teacher education programs (at three universities). The main research problem is "What kind of connection there are between these different admission procedures and students' level of proficiency in mathematics at the beginning of their studies?" This question could be specified by sub-questions as "How can we confirm the level of mathematical proficiency in new teacher students?", "How can we improve our entrance procedure, in order to select students with higher quality of mathematical proficiency?"

Admission procedures

For more than twenty years, some universities have assessed the initial proficiency in mathematics of pre-service elementary teachers using diagnostic tests, and a variety of remedial measures has been discussed, one being the inclusion of mathematics as a criterion for admission [13]. The pattern seems to have been the following: about one-third of the students admitted to teacher education in these universities have completed the advanced mathematics curriculum in upper secondary school; about one-third have completed the general curriculum and done mathematics as one of their subjects on the Matriculation Examination (ME); and the last third have completed the general curriculum but not done mathematics on the ME. About one student in ten has real difficulties on diagnostic tests in tasks involving very basic skills; as a rule, these students come from the last third. [13]

In summer 2002 and 2003 admission to elementary teacher education in Finland comprised two phases. The first phase was the national joint application procedure, where applicants from all over Finland could apply to any of the teacher education programs in Finland. In this phase points were awarded for five component tests of the Matriculation Examination and for any additional merits (e.g., teaching experience or previous university studies). In Finland the ME has been a very extensive written examination and as such has had an important role in the admission procedure. A satisfactory score on the ME on the test of the advanced upper secondary mathematics curriculum yielded additional points in the first phase of the joint application procedure. Yet, it had no bearing on the outcome of the second phase of the admission.

The second phase of admission procedures to elementary teacher education varied somewhat at different universities. Here we focus on the admission procedures at three Finnish universities: Turku (TU), Helsinki (HU), and Lapland (LU). Two different groups of students were studied at the University of Helsinki: HU1 comprised of teacher students who were studying full time, HU2 of students with teaching experience who were studying part time while working full time in the schools.

In Turku, the second phase of admission procedure comprised of four components: 1) a test assessed the applicants' readiness to analyze educational topics comprehensively; 2) a group task assessed interactive skills; 3) a personality assessment measured self-image; and 4) a test of mathematics and science designed primarily to measure applicants' mathematical thinking. The inclusion of this last component had been decided upon in summer 2000, and it proved to have been the decisive criterion for about one-third (29%) of students admitted to the elementary teacher education program in that year: without this component they would not have been selected. Against presuppositions, a test of mathematics and science did not favor men, but was neutral with relation to gender. [14]

The second phase of admission procedure at the University of Lapland (located in Rovaniemi) comprised of 1) a test based on educational materials distributed at the examination, 2) a group discussion and 3) an interview. In the group session each applicant had to introduce a topic, lead a discussion and take part in discussions led by others. In summer 2002, in the University of Lapland an admission procedure (unlike that used elsewhere) did not include a written examination of assigned reading in educational science (http://www.urova.fi/?deptid=12368).

The second phase of admission procedure for the HU1 at the University of Helsinki comprised 1) short essays of educational science based on materials provided at the examination. The parts 2 and 3 of the admission procedure were the same as in the University of Lapland. The HU2 was intended for applicants with at least 16 months' teaching experience; they did not apply through the joint application procedure but, rather, those who were most successful 1) on the written examination were selected for 2) an interview and 3) teaching demonstration (http://www.edu.helsinki.fi/ktt/valinnat/hakues03.pdf).

Method

Research persons

The present study is a co-operative undertaking of the departments of teacher education at three Finnish universities—the Universities of Turku, Helsinki, and Lapland. Students ($N = 269$) at these universities differ in many respects. The universities are located in different parts of Finland and vary in enrolment. The University of Lapland is located in northern Finland. In contrast to the other two universities, the basic course in mathematics at the University of Lapland was given during the second year; accordingly, the students there who were involved in this study were chosen in summer of 2002, whereas those at the other institutions were chosen in 2003.

Data

Data for the project were collected using a questionnaire and a test. The aim of the questionnaire was to measure students' beliefs and attitudes of mathematics (for details, see [15, 16]), whereas the test revealed their proficiency in mathematics. The questionnaire and the proficiency test were administered in all three universities in autumn 2003 at the first lecture in mathematics education. Students had 60 minutes time to complete the test and the questionnaire. In this article we concentrate on the results of the proficiency test of mathematics.

The initial proficiency test contained a total of 12 mathematical tasks. The focal content areas were rational numbers and related operations (in particular division), because previous research indicates that these are problem areas [17, 18]. All in all, the initial proficiency test focused on content knowledge different from that tested in upper secondary courses and on the mathematics component of the Matriculation Examination. The tasks of the initial proficiency test measured many aspects that [7] has introduced. An example of a task measuring mainly conceptual understanding in rational numbers is, as follows: "How many numbers there are between 0.4 and 1.3? Why?" The next task measured procedural fluency: "Divide $7 \div 12$ by using long division algorithm". An example of a task measuring mainly strategic competence is: "Write a word problem for task $6 \div 24$ and solve it". The next task is measuring mainly adaptive reasoning: "We know, that $498 : 6 = 83$. How could you conclude from this relationship (without using long division algorithm), what is $491 : 6 =?$."

Analysis

We analyzed if the following factors differ between three universities (and between four groups): students' mathematics background (gender, course selection), their average upper secondary school mathematics grades and their performance on the test of initial proficiency in mathematics. We also were interested about the differences between the genders. So we made the following null hypotheses: There are no differences between the groups. There are no difference between the genders. We applied t-test to determine whether observed differences between the means of the groups can be considered statistically significant. We chose a significance level of 0.05. Finally we determined whether the null hypotheses should be accepted or rejected.

Results

Table 1 shows the share of males in each student group as well as their mathematical background from school studies.

Table 1. Students' mathematics background at the universities

	Male students	Advanced studies in mathematics in school
LU ($N = 58$)	36%	36%
TU ($N = 75$)	16%	45%
HU1 ($N = 94$)	20%	35%
HU2 ($N = 42$)	21%	12%

As Table 1 shows, Turku selected the highest proportion of students who had completed the advanced curriculum in mathematics in upper secondary school. The difference is statistically significant. The proportions of students receiving one of the top three grades (on the seven-point scale) on the test of advanced mathematics on the Matriculation Examination at the institutions studied were: TU 18%, HU1 11%, and LU 7%. There were no students at this level of achievement in the supplementary quota at Helsinki (HU2). The corresponding proportions for the students of the general curriculum were: TU 41%, HU1 35%, LU 29% and HU2 12%. The students in the group HU2 were on average ten years older than students in other groups, and they also had more teaching experience.

The highest averages for advanced mathematics can be found in the groups HU1 and TU (Table 2). The relative proportion of *excellent* (two of the top grades) varied as follows: TU 32%, HU1 29%, LU 14% and HU20%. Where the general curriculum is concerned, teacher students at the University of Turku clearly had the highest averages; the difference vis-à-vis the weaker groups—LU and HU2—is statistically slightly significant. The percentages of grades of *excellent* differ to a statistically highly significant degree among the institutions: TU 63%, HU1 36%, LU 34 and HU2 17%.

Table 2. Average upper secondary school mathematics grades of students admitted to teacher education. Scale: 4 (fail) to 10 (excellent).

	Advanced curriculum	General curriculum
LU	7.38	8.19
TU	7.97	8.65
HU1	8.03	8.13
HU2	7.40	7.28

On the initial proficiency test in mathematics the highest possible score was 50 points. The differences in scores on the test among the groups was statistically highly significant ($p = 0.000$) (Table 3). The results for the group at the University of Turku were better to a statistically highly significant degree than those for the basic and supplementary quota students at the University of Helsinki and for the students at the University of Lapland. The difference between students in the basic and supplementary quotas at the University of Helsinki was slightly significant.

Table 3. Students' performance on the test of initial proficiency

	All	Women	Men	P (gender)
LU	27.45	25.86	30.26	0.084
TU	33.36	32.94	35.56	0.027
HU1	29.13	27.58	35.26	0.002
HU2	25.73	24.28	31.09	0.063
All	29.40	28.35	32.98	0.001

Male students performed better on the proficiency test than female students to a statistically highly significant degree. The differences between the two genders in this regard varied by institution, however. The levels of significance were affected by the small number of male students at certain of the departments studied.

As Table 3 indicates, the female students at the University of Turku performed better on the proficiency test than female students elsewhere; the difference was statistically highly significant ($p = 0.000$ in all cases). The female students in the basic quota at the University of Helsinki performed better than those in the supplementary quota to a statistically slightly significant degree ($p = 0.101$). The test scores of the male students at the University of Lapland were lower than those for male students elsewhere. Owing to the small number of male students, the differences are only slightly significant. The trend on the components of the initial proficiency tests—mathematical understanding and calculation—was the same as for the test overall: the difference between universities was significant, with the students at the University of Turku achieving the best results.

The percentages of students by institution who scored in the top quartile on the proficiency test were as follows: TU 32%, HU1 29%, LU 19%, HU2 7%. Of those scored at this level on the test, 34% had completed the general mathematics curriculum in upper secondary school; of these, 65% had earned a grade of excellent on their upper secondary transcript and the rest had a grade of 8 (good). Of those scoring in the top quartile with an advanced mathematics background, 43% had a grade of excellent, 36% a grade of 8, 16% a grade of 7, and 5% a grade of 6 on their upper secondary transcript. The number of lowest grades in general and advanced mathematics was distributed rather evenly among the institutions studied.

Of the 67 students who scored in the lowest quartile on the proficiency test, 35 had completed the general mathematics test on the Matriculation Examination; only four had taken the advanced test. Seven percent of the students admitted to teacher education at the University of Turku fell within this lowest quartile, a percentage considerably smaller than at other universities. Of the ten students with the poorest performance on the proficiency test, eight had not done mathematics as part of their Matriculation Examination, and the remaining two had received the lowest grade.

Discussion and conclusion

The findings presented here allow us to conclude that there is a connection between the admission procedures and students' level of proficiency in mathematics at the beginning of their studies: the differing admission procedures at the institutions yielded different student profiles. The mathematics-science component used on the entrance examination in Turku was found to be a significant separating factor. In Turku a higher proportion of students had completed the advanced mathematics curriculum in upper secondary school. They also had comparatively higher grades on the general and advanced tests of mathematics on the matriculation examinations.

The students in the group 2 at the University of Helsinki differed from the other groups not only in their having a weaker proficiency measured by upper secondary school marks and weaker self-confidence but also in terms of other factors: They clearly had more teaching experience and they had the poorest performance on the test of mathematical proficiency. Their poor performance on the proficiency test can likely be attributed to the fact that they had been out of school longer than the others and that many of them had worked for a long time as kindergarten teachers, i.e., an occupation in which they did not teach mathematics.

The general mathematics curriculum at upper secondary level is a sufficient foundation for successful performance on the mathematical proficiency test, which measures content encountered in elementary school. To be sure, all of the students with a general mathematics background who scored in the top quartile on the proficiency test also had a grade of at least 8 on their upper secondary transcripts. However, we did not find in our study any group of students who would have performed well on the proficiency test but did not have a good grade on their transcripts. This would have been a strong argument showing that the admission procedure used in Turku was a robust one. Although the mathematics-science component of the entrance examination did not have particularly great added value, the test seems to weed out those whose level of proficiency is poor. One alternative to having an admission examination for mathematics would be to take students' grades on the Matriculation Examination into account in the second phase of the admissions process. Nearly half of those whose performance fell in the lowest quartile had not even done mathematics test as part of their Matriculation Examination.

In addition to mathematical proficiency it is important to see also the other competencies. Especially, many pre-service teachers have a negative attitude toward mathematics. Our findings from the affective domain are similar to the ones on achievement [15].

How can we improve our admission procedure, in order to select students with sufficient level of mathematical proficiency? Based on our study, we want to make some recommendations for the teacher education selection procedure: The direction in which student admission procedures should be developed largely depends on the objectives. If the aim is to have students with a sound initial proficiency in mathematics, the admission procedure used in Turku is a worthwhile option. Support for the model can be found in research conducted by [14], who analyzed the data collected from the admission examination given in 2000. They concluded that none of the four components used in admission examination in Turku played a dominant role in obtaining admission to teacher education program. Each component measured a separate dimension of the applicant's achievement. In our opinion either a proficiency test or students' mathematics grades on the Matriculation Examination should be a significant criterion in the admission process. However, the national trend in Finland has recently gone to the opposite direction: the grades on the ME have no longer taken into account in the first phase of the admission procedure.

Many studies indicate that scores on the Pre-Professional Skills Test (reading, writing, mathematics) are weak predictors of success in teacher preparation programs [19]. Considerations of predictability also prompt the question how diverse a repertoire of methods the pre-service mathematics teacher must have. A good content knowledge in mathematics is not sufficient in itself in the work of elementary teachers: one problem facing students who have been successful in school mathematics is that they may sustain teacher-centered beliefs and lack the ability to put themselves in the place of weaker pupils [20]. Didactic skills (e.g. a good pedagogical content knowledge in mathematics) and a positive attitude towards mathematics are also important elements of the teacherhood, and on these we can try to influence during teacher education. The results of our article support the view presented by [21]: it is a complex task to select the best candidates for teacher education because we must take into account so many different aspects.

References

[1] E. Pehkonen, M. Ahtee and J. Lavonen (eds.), *How Finns learn mathematics and science*, Sense Publishers, Rotterdam, 2007.

[2] K. Merenluoto and E. Pehkonen, Elementary teacher students' mathematical understanding explained via conceptual change, in: *Proceedings of the PME-NA XXIV*, (D. Mewborne, P. Sztajn, D. Y. White, H. G. Wiegel, R. L. Bryant and K. Nooney, eds.), ERIC, Columbus (OH), 2002, 1936–1939.

[3] L. S. Shulman, Those who understand: Knowledge growth in teaching, *Educational researcher* **15** (1986), 4–14.

[4] J. Lavonen, H. Krzywacki-Vainio, M. Aksela, L. Krokfors, J. Oikkonen and H. Saarikko, Pre-service teacher education in chemistry, mathematics and physics, in:

How Finns learn mathematics and science, (E. Pehkonen, M. Ahtee and J. Lavonen, eds.), Sense Publishers, Rotterdam, 2007, 49–67.

[5] J. Hiebert and P. Lefevre, Conceptual and procedural knowledge in mathematics: An introductory analysis, in: *Conceptual and procedural knowledge; the case of mathematics*, (J. Hiebert, ed.), Erlbaum, Hillsdale, NJ, 1986, 1–27.

[6] L. Haapasalo and D. Kadijevich, Two types of mathematical knowledge and their relation, *Journal für Mathematik-Didaktik* **21** (2000), 139–157.

[7] J. Kilpatrick, Understanding mathematical literacy: the contribution of research, *Educational Studies in Mathematics* **47** (2001), 101–116.

[8] M. A. Simon, Prospective elementary teachers' knowledge of division, *Journal for Research in Mathematics Education* **24** (1993), 233–254.

[9] R. Kaasila, A. Laine, M. Hannula and E. Pehkonen, Pre-service elementary teachers' understanding on division and strategies used, in: *Problem Solving in Mathematics Education. Proceedings of the ProMath meeting June 30—July 2*, (E. Pehkonen, ed.), University of Helsinki, Faculty of Behavioral Sciences, Research report 261, 2005, 83–94.

[10] P. Hartnett and R. Gelman, Early understanding of numbers: paths or barriers to the construction of new understandings?, *Learning and Instruction* **4** (1998), 341–374.

[11] D. Tirosh, Enhancing prospective teachers' knowledge of children's conceptions: the case of division of fractions, *Journal for Research in Mathematics Education* **31** (2000), 5–25.

[12] K. Merenluoto, Conceptual change in mathematics, *Nordic Studies in Mathematics Education* **10** (2005), 17–34.

[13] E. Pehkonen, Über mathematische Anfangsbereitschaften der Lehrerstudenten, in: *Mathematics education research in Finland. Yearbook 1983*, (P. Kupari, ed.), University of Jyväskylä, 1984, 93–105.

[14] J. Tähtinen and H. Maijala, Luokanopettajakoulutuksen valintakokeita kehittämässä – valokiilassa vuoden 2000 valinnat Turun yliopiston opettajankoulutuksessa [Developing entrance examinations in elementary teacher education. Focus on admissions in the year 2000 at the University of Turku Department of teacher Education], in: *Opettajaksi soveltuvuuden moni-ilmeisyys valtakunnallisesti puntaroituna*, (P. Räihä and J. Kari, eds.), Jyväskylän yliopiston opettajankoulutuslaitos, Tutkimuksia 74, 2002, 75–98.

[15] R. Kaasila, E. Pehkonen, M. Hannula and A. Laine, Pre-service elementary teachers' self-confidence in mathematics at the beginning of their studies, paper presented at ICME 10 conference, July 2004 in Copenhagen.

[16] R. Kaasila, M. Hannula, A. Laine and E. Pehkonen, Socio-emotional orientations and teacher change, *Educational Studies in Mathematics* **67** (2008), 111–123.

[17] M. Hannula, H. Maijala, E. Pehkonen and R. Soro, Taking a step to infinity: Student's Confidence with Infinity Tasks in School Mathematics, in: *Third European Symposium on Conceptual Change—A Process Approach to Conceptual Change*,

(S. Lehti and K. Merenluoto, eds.), University of Turku, Department of Teacher Education, 2002, 195–200.

[18] S. Huhtala and A. Laine, Mini-theories as part of pupils' views of mathematics—division as an example, in: *Democracy and participation—a challenge for special needs education in mathematics. Proceedings of the 2nd Nordic Research Conference on special needs education in mathematics*, (A. Engström, ed.), Reports from the Department of Education, Örebro university, 7, 2004, 177–188.

[19] A. Mikitovis and K. Crehan, Pre-professional skills test scores as college of education admission criteria, *Journal of Educational Research* **4** (2002), 215–223.

[20] R. Kaasila, Using narrative inquiry for investigating the becoming of a mathematics teacher, *ZDM – International Journal of Mathematics Education* **39** (2007), 205–213.

[21] M. Caskey, K. Peterson and J. Temple, Complex admission selection procedures for a graduate preservice teacher education program, *Teacher Education Quarterly* **4** (2001), 7–21.

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