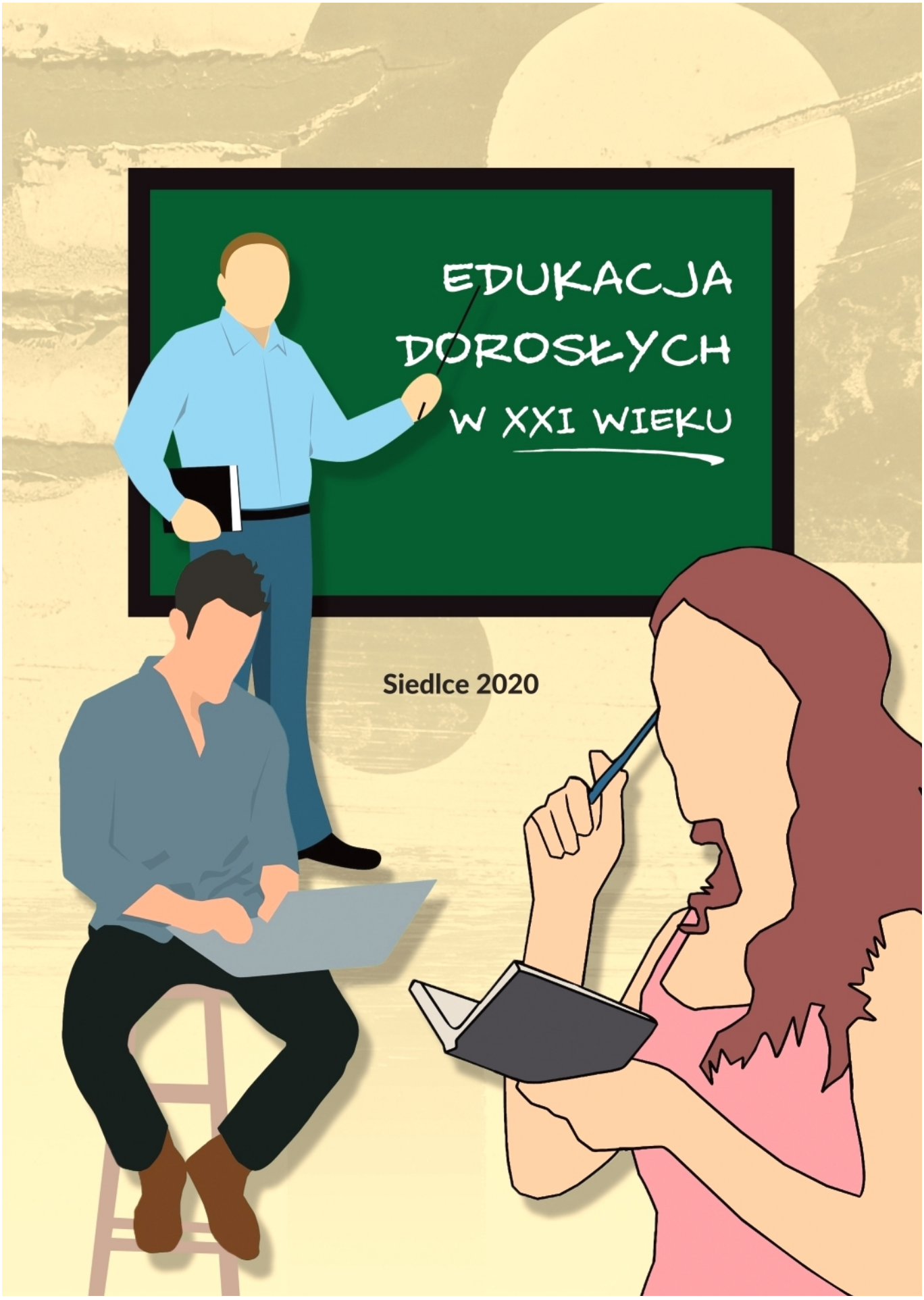

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BRIDGING COURSES FOR MATHEMATICS AND SCIENCE TEACHER STUDENTS: EXPERTS' POSITION

A B S T R A C T

Transition from one study stage to another is not an easy thing. Graduates, who have chosen university studies, quite often face various academic difficulties. In many countries, universities preparing natural science and mathematics teachers hold so-called bridging courses at the beginning of studies. The main purpose of such courses is to decrease the gap between what was learnt at the secondary school and what is necessary at university. In Lithuanian universities, preparing future teachers, bridging course application practice is very poor. It is known very little about the demand of such courses, possible content, structure, realization possibilities. This creates a clear problematic field.

A qualitative research was carried out, in which 11 Lithuanian university lecturers-experts took part. The collected data was analysed using content analysis method. It was ascertained that the demand of bridging courses existed, and the students, who have entered a higher school, had school knowledge gaps, which could be at least partly fulfilled by appropriately prepared and realised such courses. It is difficult to evaluate the influence of a bridging course on students' academic achievements without conducting a detailed research, however, if such courses were included in the programme, it is likely that the students' study results would be better.

Keywords: bridging course, content analysis, qualitative research, university students.

INTRODUCTION

Bridging courses are not a new educational practice for university students, however, this sphere is significant and problematic. First of all, for the reason that there are bigger possibilities to obtain higher education, and this, in turn, means that different types of students begin higher education studies. According to Nicholas and Poladian [8], the number of students, whose maths preparation is insufficient to study maths programmes at university, is getting bigger. A similar situation is also with natural sciences. This is especially

true for future teachers of natural science and mathematics. Quite often, their preparation at a secondary school for such field studies is very different because of various reasons. In one way or another, there exists a gap in knowledge between secondary school and university [6]. Therefore, it is important that universities make conditions for the students free of charge, voluntarily, at a personal pace and time, with the help of technologies to increasingly strengthen the knowledge and abilities in a particular field. Such teachings at universities are very often carried out remotely. The main aim is to assure qualitative starting positions for all students, and to improve basic knowledge brought from the school course. This, in its turn contributes to the assurance of common study quality, because as it is known, the quality of higher education cannot be independent neither from science and studying policy of a certain country nor from a policy of a particular university [5]. Besides, the researchers assert that emphatic teaching, administration and attendance staff accepting individual students' traits is not less important [3]. It is also a significant factor, helping students to successfully adapt to university life and to finish studies. Pedagogical component of these studies is very important. Future teachers of mathematics and natural science not only study a particular science field, but also acquire education (pedagogy) science knowledge. The researchers notice that pre-service teachers should also be provided with more structured opportunities to help develop pedagogic content knowledge [12]. Thus, quite often various bridging courses or bridging programmes are carried out at universities [10]. However, there is still little research grounding such course/programme effectiveness [9]. The results of the research carried out in Australia showed that students understand the value of a bridging course not only seeking to solve the previous math learning difficulties and to improve math teaching/learning methods, but also as a possibility of easier and more fluent transition from secondary to higher education [4]. On the other hand, students' first year study experience is important for their further study success. Finally, transition from secondary to tertiary education experience influences the academic success and positive satisfaction [11].

BRIDGING SCIENCE COURSE DEMAND IN LITHUANIAN HIGHER SCHOOLS

The duration of general education in Lithuania is 12 years, arranging education periods in structural order: 4+(4+2) +2, i.e. primary +basic +secondary education. Primary education lasts for 4 years, basic- for 6, and secondary for 2 years. Compulsory education is until 16years of age (1–10 forms, between 7–16 years of age). Primary and secondary education is a structural part of Lithuanian qualifications and correspondingly ascribed to its 3 and 4 levels, which corresponds to 3 and 4 levels of European qualification structure.

After completion of the secondary education programme and having passed school-leaving exams, secondary education is acquired giving a school leaving certificate supported by an evidence. General education is non-profiled. The received school leaving certificate gives evidence of the acquired general education. School leaving certificate in Lithuanian general education system is the only given qualification, giving the right to higher

education. School leaving certificate gives the right to enter all profile higher schools (universities and colleges) [13].

Secondary education is not compulsory and lasts for two years (gymnasium 3 and 4 forms or 11 and 12 secondary school forms). Students learn according to individual education plans. Vocational teaching programme modules can be included in the programme. According to the secondary school programme, one can study in secondary schools, gymnasiums, vocational schools [14] .

The main reason presupposing a demand of a bridging science course is coded in Lithuanian general secondary education system.

The main point is that students learn all natural science subjects (physics, chemistry and biology) up to the 10^{th} form. In the 11^{th} -12^{th} (3-4 gymnasium) forms, only one of all natural science subjects or an integrated natural science course is compulsory. Students have to choose to learn one out of three natural science subjects. GENERAL AND SECONDARY EDUCATION PROGRAMME GENERAL EDUCATION PLANS FOR THE SCHOOL YEAR 2019-2020 AND 2020-2021 [15]. Besides, taking into consideration their demands and inclinations, students can choose a general or an expanded natural science subject – biology, chemistry, or physics course (Secondary education general programmes: Natural science education [16]. 140 hours are assigned to the general course, and from 210 to 245 hours to the expanded course.

Therefore, students of a very different level of knowledge and abilities gather to Lithuanian university auditoriums.

The research aim was to analyse university lecturers', who participate in preparing mathematics and science teachers, position regarding bridging courses (their demand, structure, content, etc.).

RESEARCH METHODOLOGY

General Background

A qualitative research was carried out in the months January to February 2020 (expert survey). The research was carried out with experts in the method of e-communication. Expert survey method was chosen seeking to present the position of the lecturers having big practical experience in preparing teachers, and also to get real suggestions regarding the bridging course preparation.

Sample

Eleven (11) lecturers from two Lithuanian universities preparing teachers participated in the research. The latter are treated as natural science and /or mathematics (their didactics) lecturers- experts, able to provide a competent opinion on the examined question. Information about the experts who participated in the research is presented in Table1.

Table 1. Demographic information

Expert type	Name, surname	Institution	Subject, field
University lecturer	Aušra Kynienė	Vilnius university	Physics, physics didactics
University lecturer	Edmundas Mazėtis	Vilnius university	Maths, informatics
University lecturer	Rimantas Raudonis	Vilnius university	Chemistry, chemistry didactics
University lecturer	Eugenija Rudnickaitė	Vilnius university	Geology, non-formal education
University lecturer	Grita Skujienė	Vilnius university	Biology
University lecturer	Gintautas Stankūnavičius	Vilnius university	Meteorology
University lecturer	Renata Macaitienė	Šiauliai university	Maths, maths didactics
University lecturer	Ilona Kerienė	Šiauliai university	Chemistry, chemistry didactics
University lecturer	Laura Šukienė	Šiauliai university	Biology
University lecturer	Violeta Šlekienė	Šiauliai university	Physics, integrated natural science didactics
University lecturer	Dainius Balbonas	Šiauliai university	Engineering, electronics

Carrying out this qualitative research, the basic ethical principles were guaranteed: benevolence, voluntariness, and the right to receive exact information.

Instrument

The experts having participated in the research were asked to express their opinion according to the presented questions:

- What natural science subjects do you teach/taught at university?
- Do you feel students' school knowledge, ability gap, having started to teach your subject?
- What subject and what level school knowledge do the students lack?
- What is your opinion about the bridging course necessity for the first-year students?
- Would such course fulfil school knowledge gaps of your taught subject?
- Would the students' study results be better, in your opinion, if a bridging course was included in a study programme?
- Please write your opinion, what the bridging course content should be for the first course students.
- Please write your opinion, how such bridging course should be organised (lectures, trainings, practical works, consultations, etc.)
- Please write your opinion about the other possible, in Your opinion, solution ways of this problem.

The questions were prepared taking into consideration the activities foreseen in the international project "Bridge2Teach" application.

Data Analysis

The collected data was processed using content analysis method. Content analysis was chosen as the most appropriate way to analyse not numerous information and taking into consideration the research aim, to present the generalised results [1] [7]. This is a technique that allows the classification, comparison and interpretation of the texts [2]. During the analysis, the examined text was read several times by two researchers independently.

RESEARCH RESULTS

Eleven (11) lecturers from different Lithuanian universities having great subject matter and pedagogical experience in natural sciences (physics, chemistry, biology, geography, engineering, maths) participated in the expert survey about **natural science and maths bridging courses for students and their demand**. All surveyors agree at a different level that students who enter a higher school have school knowledge gaps which could be at least partly filled by appropriately prepared and realised bridging courses. However, almost everybody notices that this is not an unambiguous problem and that it does not have one truthful solution.

Generalised insights of the lecturers on every question aspect are presented in the table 2.

Table 2. Experts opinion based on some variables

No	Variable	Generalised comments
1.	Natural science subjects being taught/ have been taught at university	Lecturers, having participated in the survey, teach these their field subjects at university: • physics (*general physics, physics didactics, natural science education didactics, algorithms and programming, physics history*); • biology (*invertebrate zoology (practice), evolution biology, pedobiology (malacological part), bioethics and biotechnologies, biological diversity protection, studies of protected biota, environment and biota observation and assessment, invertebrate biology and ecology*); • chemistry (*general chemistry, organic chemistry, environmental chemistry, ecology*); • geography, geology (*hydrology, meteorology and climatology, general biology; mineralogy; geological cartography basics, synoptic meteorology basics, introduction to dynamical meteorology and weather forecasting, remote methods in hydrometeorology, long-term weather forecast methods, global circulation modelling*); • engineering (*electronics, chain theory, fundamentals of physical electronics, car sensors, sensor networks, computer communication, human and computer interaction, electronic system programming, metrology and measurement basics*), maths (*geometry, linear algebra, mathematical analysis, financial measurement, probability theory, computer statistics, function theory of a complex variable, statistical eval-*

		uation of ecological data and modelling, analysis number theory, differential equations)
2.	The evaluation of students' lack of school knowledge and skills having started the studies at university	All the surveyors claimed that having started to teach their subject at a different level they felt students' lack of school knowledge and skills.
3.	The evaluation of students' lack of school knowledge	Having generalised the lecturers' answers, one can discern five main spheres of school gaps: **natural science and maths school knowledge, practical research abilities, IT skills, ability to think, independent work skills.** • A lack of natural science and maths school knowledge. It is felt that students' fundamental subject school knowledge level is not the same. Basic knowledge of physics, chemistry and biology, geography of most first course students is weak. Especially of those who learnt one or another natural science subject only up to the 10th form inclusive. Students have poor nature cognition skills – very often they do not recognise even a strawberry, a May bug, a crow, not to mention the other animals. Very frequently they do not know the main regularities, standard formulas of physics and chemistry course. They cannot tell the difference between a physical unit and its mathematical value, i.e. – attention is not paid to measurement units. Therefore, they can perform mathematical operations with different measurement units, e.g., to add grams with kilograms. There is a lack of basic maths course knowledge, poor knowledge of the basic geometry, they do not know trigonometry functions, cannot calculate fractions, solve quadratic equations, especially if they are not in numerical expression but in literal. They are bad at algebraic phenomena identity reconstruction, inequation solution, logarithms. They do not perceive the concept of a derivative. A lack of maths knowledge depends on the study programme the students have chosen. The main thing is – a lack of ability to perceive mathematical statements or to give a proof of an elementary formula. The problems happen with the formula conversion (necessary unit expression). There is no "mathematical intuition". Such operations as multiplication or division by 10 (or 100, 1000) are performed with the calculator (cannot do it in the mind). As for physics – attention is not paid to measurement units. Therefore, one unit is written e.g., in joules, another – in kilojoules. They cannot see logical relationship. Such problem is less noticed in the study programmes of maths because students having adequate preparation choose this direction of studies. A lack of mathematical knowledge is observed and is rather distinct in other direction study programmes. • Weak practical research skills. Practical skills of work in laboratories are very minimal. Completely do not have skills in scientific work planning, making projects and writing. Are not able to evaluate the precision of the result, reliability, do not know methods of bias calculation and their meaning. Do not understand that one result is unreliable, that science requires a lot of (statistically reliable quantity) repeated experiments. • A lack of IT skills. Some students have limited skills and knowledge how to use Microsoft Office programme tools because IT education programmes in schools are more oriented to programming. The majority of students cannot do basic calculation in excel, and cannot use graphic drawing elements. • –A lack of ability to think. Students are not sufficiently taught to think at school. Do

		not have understanding about natural science and mathematical concepts, reasoning, and at best, they have mastered only mathematical procedure of algorithm performance. They cannot see logical relationship. With difficulty discern essential features of the concept from non-essential, are not able to trace cause and consequence relationship, i.e., unable to define, what is cause and what is consequence. • Poor independent work skills. There are no independent work skills. Students who pay for studies usually show worse knowledge and worse abilities to study independently. They lack independence, ability to analyse literature sources and to cite them properly.
4.	The evaluation of bridging course demand for the first course students	All lecturers having participated in the survey indicate that bridging course for the first course students would be necessary, and that such course would help to fill school knowledge gaps. At the same time lecturers note that such course demand should be individual for every future student, one should decide about student's level only after testing him, or at least according to school marks of that subject. It is stated that this would be useful because a lot of dear time is wasted for the revision of basic things or for the acquisition of them, which should be devoted to subject mastering. Bridging courses would provide a possibility to study natural sciences for students, who studied the subject at B level at school, or did not choose it at all. Therefore, bridging course e.g., chemistry, would be useful for the first course students, who finished learning chemistry in the 10th form. The gap between the knowledge of the first course students would be significantly smaller. On the other hand, bridging courses would be a perfect possibility not only to fill the gaps, but also to systemize the possessed knowledge, necessary for studying at a higher school. However, lecturers having practice with similar courses notice that this is not a panacea. They claim that their use is just the same as of any other study programme course – more diligent and more hard working (who have less of these gaps) definitely receive more benefit from these courses, but the weaker ones, who do not try and do not take such courses seriously, improve very little. Besides, it is noticed that it is problematic to insert such course in the study programmes. Those, who do not need such course, will have to get something instead of a bridging course. That is, they will go further, and again a difference will form between those who stayed in the bridging course and those, who stuck to already a new course. Those, who will be in the bridging course, can feel themselves second rate, inferior.
5.	The assessment of study programme supplement with bridging courses	In lecturers' opinion, students' study results would be better if bridging courses were included in the study programme. Some think that one could have a higher evaluation by 2 points in some subjects, or that a subject study quality would improve not less than 25 %. This depends on the learner. On the other hand, lecturers notice that without carrying out research, it is difficult to assess bridging course influence on students' achievements.
6.	Bridging course for the first course students content evaluation	Speaking about bridging course content, lecturers unambiguously claim that this depends on a chosen study direction (even on a study programme), because necessary knowledge basically differs for the students having chosen physical, technology or social sciences (educology) study programmes. Bridging course content could be related to the planned to teach subject topics, or it might be even included in its programme. However, the topics, that have been studied

		in gymnasium classes should be included (all higher school students perfectly know general school course). Basic knowledge of biology, chemistry, physics is necessary. For the engineering studies, it is necessary to revise electricity course in physics (Ohm's and Kirchhoff's laws, electromagnetism), also, one should revise mechanics course (movement, forces, vectors). For the physics studies, basics of maths and geometry are necessary, abilities to apply maths knowledge in physics, planning and carrying out of the research work. Identity reconstruction, degree and logarithmic phenomena reconstruction, equation and inequation solution, trigonometry and other topics should be included in maths bridging course. But the most important thing is not to limit oneself in only revising procedures but more attention should be devoted to concept formulation, giving proofs, ability to make an argument and to make conclusions because, when a student masters the essence of maths, it will be easier for him to learn any maths unit.
7.	Bridging course organisation (lectures, trainings, practical works, consultations, etc.) evaluation	Speaking about bridging course organisation, it is accentuated that student work of such course could be organised in the first half of the studies, assuring the quality of the studies as in the traditional lectures – providing theoretical knowledge, developing working in a laboratory and other practical skills. All traditional education forms are suggested, i.e. lectures, practical training, practical/laboratory works, projects, consultations. In many lecturers' opinion, there shouldn't be a lot of lectures, the main work should take place during practical activities, where the students should not only revise school course, but also discuss, learn to make arguments, give proofs, search for rational solutions, compare various solution ways. The opinion was expressed that one month of intensive bridging course would be enough: some lectures, practical training, practical (laboratory) works, consultations, and a possibility is made to consult the bridging course lecturer also after the course. Another opinion was that not a separate bridging course would be necessary, but consultation systems introduced to the common course of the whole stream. Periodically formative evaluation should take place and the concrete gaps, having come to light, should be filled arranging consultations.
8.	Evaluation of other possible solutions	Additional thoughts about possible ways of this problem solution: • Everyone should have the same level of fundamental subject knowledge. Chemistry, physics, geography, biology, etc. should not be attributed to optional subjects. • An appropriate State policy would increase the motivation to choose bridging courses and would guarantee the students a possibility to study for free. • To evaluate the level of knowledge of the accepted students would be best taking into consideration the studied specialty and to include additional activities in the first course (local solution). The main problem is complex: a lack of motivation, discipline, and a lack of positive attitude to natural sciences, their unpopularity at school. • This problem would be solved best only when students were taught not only procedures at school, but also maths concepts, were trained to strict and consequent teaching. But this is already not within our competence, ministry has to do this restructuring teaching programmes. • To change maths general and secondary education programme. • For those who did not learn the subject or learnt it at B level, every week to organise extra revision of school course (of those subjects, which were important for the given course).

		• Maths is a specific science in this sense that in order to understand it, work is necessary in the auditorium (explaining, clarifying). So, practical activities - is the best form to deepen knowledge and skills.

CONCLUSIONS

All participators in the survey at a different level agree that students, who have entered a higher school, have school knowledge gaps, which could be at least fulfilled by appropriately prepared and realised bridging courses.

Having generalised lecturers' answers to the question about the lack of school knowledge, abilities and skills, one can discern five main school gap spheres: lack of natural science and mathematics school knowledge, weak practical research abilities, lack of IT skills, lack of ability to think, poor independent work skills.

Almost all lecturer experts notice that bridging courses are not an unambiguous problem, and that it does not have one right solution. They accentuate that such course demand for every future student should be individual; they indicate that it is problematic to insert such course in the study programmes.

It is difficult to evaluate the bridging course influence on the students' achievements without conducting a detailed research, however, in lecturer-expert opinion, if bridging courses were included in the study programme, students' study results would be better.

Lecturers-experts unambiguously claim that the bridging course content depends on the chosen study direction (even on the study programme), because basically necessary knowledge for the students who have chosen different study programmes differs. The most important thing is not to limit oneself only in fact or procedure revision, but more attention should be paid for concept formulation, proofs, for the ability to make arguments and to draw conclusions, because when a student masters the essence of the subject, it will be easier for him to study any subject unit.

Lecturer-expert opinions about the bridging course organization were different. The majority offered all traditional education forms, i.e. lectures, trainings, practical/laboratory works, projects, consultations, accentuating that there should not be many theoretical lectures, the main work should take place during practical activities, where students would not only revise the school course, but would also discuss, learn to make arguments, make proofs, look for more rational solutions, would compare various solution ways.

Note

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