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Choosing Exact Science Subjects in Lithuanian Secondary School

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Abstract: The National Progress Strategy "Lithuania 2030" raises a goal to form the conditions for the learners' individual development and expression of creativity, implementation of joint ideas by business and science. The National Education Strategy for 2013–2022 specifies that the Lithuanian education must become a sound basis for improving well-being of the state, a dynamic and independent person creating his own future, future of the state and the world in a responsible and solidary way. It should be noted that Lithuania has achieved a lot in the area of education accessibility: we are one of the leaders in the European Union by the level of working-age persons (of 25–64 years old) having at least secondary education, in the top-ten — by the level of higher education of the youth (of 30–34 years old). However, we have some social isolation risk groups, in particular among the youth, who have difficulties in integrating into the labour market, we lack attention for the gifted ones, lag behind the leading countries by the achievement of the learners' highest levels, there are significant differences between education accessibility and quality in a city and in a village, there remain some unsolved problems related to the contents of education and studies. In this context some problems also arise in the implementation of a profile education (self-education) model in general education schools. The choice of subjects and their learning levels has not only an academic basis but it is also one of the main factors predetermining the success of the career development in the future. The article overviews the priorities and motives of the Lithuanian general education school learners of the 11th–12th forms (N = 1,019) for choosing the exact science subjects and compliance with their future plans of the professional activities or studies.

Key words: subjects of exact and natural sciences, individual learner's education plan, motivation for choosing subjects, reflexion of a choice

1. Introduction

Until the year 2000 in the Lithuanian general education schools learners were taught (learning) following a single curriculum, when all the learners learnt the subjects foreseen therein at the same level. This guaranteed that the learners graduating from secondary school will acquire equal knowledge and abilities of different sciences as well as will have the same preparation level when choosing further studies or other professional activities.

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However, such a unified teaching (learning) also had its own minuses, for example, the learners of different needs and tendencies instead of paying more attention to the purposeful development of the abilities necessary for their future career were forced to pay great attention to those subjects, which were of less importance to them. The learners who were good at a certain field not always succeeded in learning the subjects of other fields. Moreover, such compulsory learning of all the subjects was a greater strain on the learners who were not so good at learning, thus, teaching (learning) results started deteriorating, and the number of unmotivated learners and the ones who did not attend school was increasing. Taking into consideration the experience of other countries, in 1998 a profile learning method was approved, which was experimented and adjusted for several years. The general profile teaching was introduced in national general education schools in 2000. By the introduction of the choice of subjects and their learning levels, the Ministry of Education and Science of the Republic of Lithuania aimed at an increase in learners' learning motivation, decrease in teaching (learning) strains, individualisation of the education (self-education), creation of the conditions to acquire more thorough and more purposeful knowledge by expedient orientation towards the chosen field of the professional activities or further studies, choice of the subjects meeting the learning course and different its learning levels taking into consideration the learners' aims, needs, tendencies, experience and abilities possessed, enhancement of prevention against dropping out from the education system, etc. (Telešienė, Adaškevičienė, Urbonaitė – Šlyžiuvienė et al., 2005).

In the implementation of the changes in the Lithuanian education system the situation in national schools has changed in essence: there was a transition to a 12-year education cycle, a system of the structure of schools is under reorganisation, new primary and basic education (in 2008) as well as secondary education (in 2011) curricula were approved, new Lithuanian textbooks were published, number of lessons of exact science subjects was significantly reduced, in 2010 a higher education reform was started to be implemented, etc. In reforming the general education system there was a transition to such a profile teaching method when in the 11th–12th learning and teaching years the learners learn following individual education plans, the goal of which is to help the learners to plan how based on their own possibilities to achieve higher learning results, self-develop personal responsibility by consciously learning to implement the goals set (Mokslo metų pagrindinio…, 2013–2014, 2014–2015). About 60% of an individual self-education plan includes a general education content compulsory to everyone: a block of the Lithuanian Language and Literature, Foreign Language, Mathematics and Physical Education, optional one subject of Ethics, Arts and Technology Education each and at least one subject of Social (History, Geography, Economics) and Natural Sciences each (Physics, Chemistry, Biology). The level of learning compulsory subjects is chosen by a learner himself. The remaining part of the plan includes the content chosen by a learner: additional subjects of the compulsory content, expanded courses of the chosen subjects, modules of the subjects and optional subjects. The learner coordinates his/her individual self-education plan with the possibilities of a school or chooses from the options suggested by the school. However, total number of weekly lessons of this plan should not exceed 32. Furthermore, the cycle of the secondary education ends with a state Lithuanian Language examination compulsory to everyone. In order to receive a Maturity Certificate a school leaver has to have passed a maturity examination of at least one subject, and when continuing studies in different Lithuanian universities he/she has to have passed maturity examinations of at least three subjects. However, the number of maturity examinations cannot exceed 5 examinations. Such limitation on the number of lessons and examination as well as necessity to choose the subjects of the aforementioned blocks rather significantly limit the learners' opportunities to choose and their future professional career.

A practical situation in the faculties of exact and natural sciences in the Lithuanian higher education

institutions, results of state maturity examinations and entrance to higher education institutions show not only the advantages but also disadvantages of such profiling. Such a teaching (learning) model partially limits the opportunities and priorities of school leavers to choose further studies and professional activities, as learners' plans and expectations constantly change, while real possibilities to change the chosen subjects and their learning levels are problematic (Kaminskienė, Rimkuvienė & Laurinavičius, 2010; Valstybinių brandos egzaminų..., 2004–2014). Moreover, a certain negative attitude towards the importance and necessity of learning exact sciences has become dominant in the society. As rapid changes take place not only in the Lithuanian education system but also in the economy, in the science development it is important to establish how the current practice of choosing subjects and their learning levels meets the future learners' career goals, what trends of such a choice become evident in view of compliance between the learners' needs and opportunities, choice motives and other aspects. There are not many available more exhaustive researches on the impact of the learners' choice of compulsory subject learning levels and additional learning content both on the future expectations of the country and the learner. Though there could be mentioned the research "Problems of Profile Teaching" carried out by the order of the Ministry of Education and Science in 2005 (Telešienė, Adaškevičienė, Urbonaitė – Šlyžiuvienė et al., 2005). Therefore, in 2014 the authors of the article aiming at *identification of the priorities and motives of the senior form learners from the Lithuanian secondary schools and gymnasiums for choosing the exact science subjects and their compliance with future plans of the learners' professional activities and studies* carried out a research. The results presented in the article should be of interest to the education process organisation specialists of different levels, teachers, parents and learners themselves.

2. Overview of Mathematics Content

The scope of exact sciences and their courses following the national secondary education (the 11th–12th learning years) curriculum is presented in Table 1.

Table 1 Scope of Exact Sciences and Their Courses in the Secondary Education Curriculum

Subjects	General course		Expanded course	
	Number of weekly lessons	Scope of the curriculum within 2 years (*hours*)	Number of weekly lessons	Scope of the curriculum within 2 years (*hours*)
Mathematics	3	210	4–5	310
Information Technology	1	70	2	140
Physics	2	140	3–4	245
Chemistry	2	140	3	210

Mathematics is the only subject of exact sciences, which is compulsory to everyone. Learners may choose either the general or the expanded course of Mathematics, or they may choose also extra modules of the subject, which are suggested by Mathematics teachers of the school. Other subjects of exact sciences discussed in the article (Information Technology, Physics and Chemistry) are not compulsory in the 11th–12th learning years. The learners, who choose Information Technology, Physics and Chemistry, learn them like Mathematics following the curricula of the general or expanded course of these subjects.

We will overview in brief the education content of Mathematics. In the 11th–12th years the learners, who learn following Mathematics general course content (Vidurinio ugdymo bendrosios programos, 2011), examine real numbers and expressions (sets and subsets of numbers, progressions, degrees and radicals, logarithms),

functions, equation, inequalities and their systems (rational and irrational equations, inequalities and their systems, simple power, exponential, logarithmic and trigonometric functions, simple exponential, logarithmic and trigonometric equations), differential calculus (concept of derivative, derivatives of functions expressed in polynomials, extreme of the function, monotony intervals, investigation of simple functions and graph drawing), geometry (repetition and review of geometry knowledge of a basic school, similar polygons, central and inscribed angles, sine and cosine propositions, spatial bodies, lines and planes in space, dihedral angles), probability theory and statistics (elementary events, classical probabilities and their properties, key concepts of statistics, data collection and representation, numerical characteristics of the sample).

The learners, who choose the expanded course of Mathematics, additionally familiarise with the concept of sequence, infinitely decreasing geometric progression, formulas of sum and difference as well as of sum and difference of cube, elements of approximate calculation, equivalence of equations and its application, transformations of graphs of functions, concept of inverse function, trigonometric identities, derivatives in geometric and physical senses, derivatives of exponential and trigonometric functions, primitive functions and simple integrals as well as their application for squaring, regular polygons, Thales' theorem, vectors, combination calculation formulas, general definition of a probability and properties of a probability, Bernoulli scheme, binomial distribution. In the expanded course not only new topics are analysed but also the questions of the general course are examined in more detail. Moreover, in the expanded course, as different from the general one, the learners must know how to prove theoretical statements, for example, Vieta's, Pythagorean, Thales', sine, cosine and other theorems.

3. Research Design

In order to realise the goal of the research the authors developed a questionnaire where the learners had to indicate their chosen subjects of exact sciences (Mathematics, Information Technology, Physics and Chemistry) and their learning levels, number of weekly lessons, intention to take state examinations of these subjects, planned further studies of different science fields, to name their attitudes towards exact sciences and learning levels of the subjects chosen, motivation for choosing the subjects, etc. The questionnaire consisted of 18 questions: ten of them included from 4 to 10 statements or elements, measured by a 3-point or 5-point Likert scale items *no, don't know, yes* or from *strongly disagree* to *strongly agree*. 1,019 learners from schools of different Lithuanian regions took part in the research: 47.3% — the ones learning in the 11th school year and 52.7% — the ones learning in the 12th school year. 49% of the learners who participated in the survey were from schools in cities and towns, 32.2% — in municipality centres and 18.8% — in villages. For processing of the research results the Mathematical statistics methods (Čekanavičius & Murauskas, 2000; Sirkin, 2006) and SPSS software package were employed. In the analysis of the research data through the section of the individual learning year, no statistically significant differences were established, thus, the results are presented jointly for the learners of both learning years.

4. Results

4.1 Statistics of Choosing the Subjects

As it has already been mentioned, Mathematics is the only subject of exact sciences, which is compulsory to everyone. The learners are free to choose only Mathematics teaching (learning) level. The learners are allowed not to choose other subjects of exact sciences (Information Technology, Physics and Chemistry) at all or to choose to

learn a general or expanded course of one or several desired subjects or also extra modules of the subjects chosen. The Chart in Figure 1 presents the data on the frequencies of choosing individual exact science subjects and their learning levels.

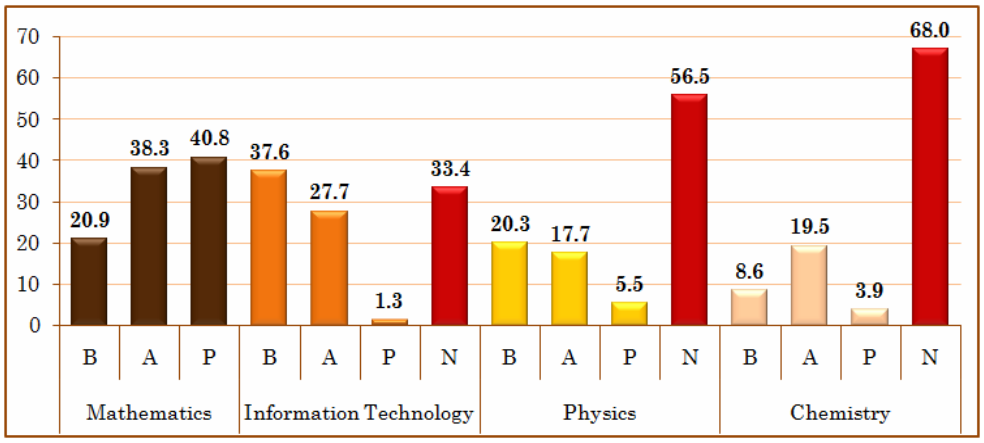

Figure 1 Level of Learning Exact Sciences (%, N = 1,019)
(B – General course of the subject, A – Expanded course of the subject, P – Course of the subject with extra modules, N – Did not choose the subject)

Almost 80% of the respondents learnt Mathematics following the expanded course curriculum or chose also its extra modules. The Information Technology was not chosen by one third of the learners, while Physics and Chemistry were not chosen even by about 56% and 68%, accordingly. It should be noted that higher Chemistry learning level was chosen by even 73%, Physics — by 53%, and Information technology — just by 43% of all the learners who learn these subjects. Although the requirement for information technology specialists is constantly increasing both in the country and in the world, a major share of the learners of the country limit themselves only to acquisition of basic competences of the information technology user. Most often a higher learning level was chosen by the learners form larger urban (of towns and district municipality centres) schools ($x^2 = 19.7$; df = 2; $p < .0001$).

Better learners' achievements are predetermined by the learners' efforts to learn. As a weekly number of lessons is not big, a share of the learners aiming at better knowledge and abilities of the subject were learning these subjects additionally. More than a half of the respondents were learning individually, one fourth was helped by tutors or family members, slightly more than one tenth attended extra-curriculum activities, courses both in school and outside it. In the analysis of the data on additional learning of exact science subjects it was noticed that Mathematics is learnt additionally by every third respondent, while the Information Technology, Physics and Chemistry — by much fewer number of learners (see Figure 2). None of the subjects is learnt additionally by only every fifth learner. Out of other subjects most often the learners additionally learn a foreign (in particular, English) and/or the Lithuanian language.

In the analysis of the links between the learners learning a subject additionally and the choice of the learning level of this subject, it was noticed that the learners who chose a higher level give greater focus on this subject not only during the lessons but they also take additional interest in this subject (x^2 fluctuates from 37.3 to 91.5; df = 2; $p < .0001$). Moreover, the learners who are good at Mathematics and for whom it is important for their future professional career, as a rule, additionally learn not only Mathematics but also Physics (x^2 fluctuates from 8.2 to 24.1; df = 2; $p < .05$ and $p < .001$). Those respondents, who are good at Information Technology and Physics and

for whom these subjects are important for their future professional career, most often learn them additionally (x^2 fluctuates from 7.7 to 40.8; df = 2; p < .05 and p < .001), and those who are good at Chemistry and for whom it is important learn not only Chemistry but also Physics additionally (x^2 fluctuates from 11.9 to 162.6; df = 2; p < .001). However, as the research results show, additional learning of exact science subjects is not related to the learners' achievements in these subjects.

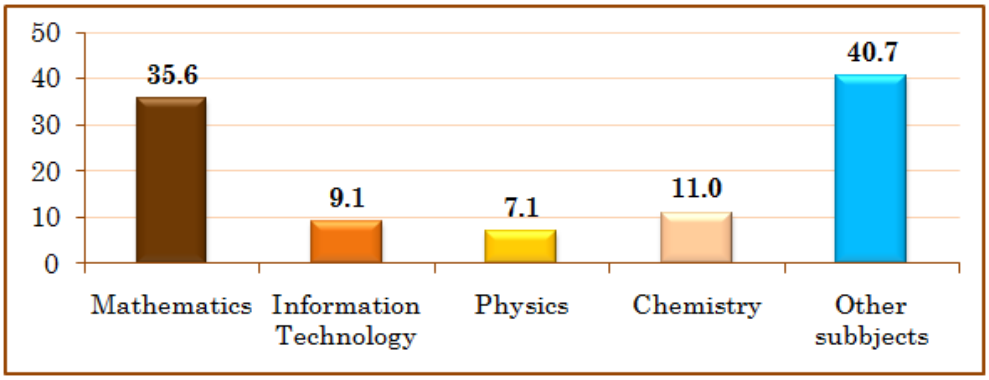

Figure 2 Additional Learning of the Subjects (%, N = 1,019)

Attractiveness of a subject, better learning achievements largely depend on the teachers' competence. In the analysis of the learners' attitude towards the teachers of exact science subjects, even 81% of the respondents stated that they were taught by a good Mathematics teacher. 65% of the respondents had a good Information Technology teacher, 54% — Physics teacher, and 41% — Chemistry teacher. The learners who had good Mathematics teachers more often were choosing to learn this subject at a higher level ($x^2 = 28.4$; df = 4; p < .0001). Whereas the learners who had good Information Technology, Physics and Chemistry teachers, on the contrary, were choosing a lower learning level of the subject. Such results may be related to the limited number of weekly lessons or that the learners are more willing to learn the subjects of humanities and social sciences at a higher level. Furthermore, it was observed that the achievements of the learners with good teachers are higher (x^2 fluctuates from 8.4 to 32.1; df = 2; p < 0.05 and p < 0.0001).

4.2 Factors Motivating the Choice

In the analysis of the learners' attitude towards the subject, it was established that Mathematics is an interesting subject, which is liked to be learnt by about 60% of all the respondents. An analogous opinion about Information Technology was expressed by 50%, about Physics — 35%, while about Chemistry — just by 25% of the learners. Almost three quarters of the respondents stated that Mathematics is important for their future career; whereas the importance of Information Technology, Physics and Chemistry for the future is conceived by much smaller share of the respondents (by 51%; 33% and 32%, accordingly). The fact that they are good at Information Technology was indicated by the largest share (almost 60%) of the learners, and the ones who are good at Mathematics, Physics and Chemistry represented 48%; 38% and 28% of the respondents, accordingly. As a rule, the learners having a favourable opinion about the subject most often chose a higher level of learning that subject (x^2 fluctuates from 17 to 97; df = 2; p < .0001).

The learners' intentions to take a state maturity examination of this subject are no less important factor of choosing a subject and its learning level. The research data shows that 73% of the respondents plan to take state maturity Mathematics examination. Such a result is partially predetermined by that the assessment of this maturity

examination is important not only when entering the study programmes of exact sciences but also many other popular study programmes. Whereas despite the increased requirement for the specialists of information technology, only 16% of the learners learning this subject plan to take Information Technology examination. A similar share of the respondents plan to take also state Physics and Chemistry examinations. Statistical analysis of the data shows that the learners who chose higher levels of learning exact science subjects, as a rule, more often plan to take state maturity examinations of these subjects (x^2 fluctuates from 113.9 to 470.1; df = 2; p < .0001).

One more very important criterion for choosing the exact science subjects and their learning levels is an external motivation of the learners. The greatest impact on choosing these subjects, as it was pointed out by the learners, is made by the opinion of family members and relatives, information by higher education institutions (their websites, advertisements, meetings with representatives of higher education institutions, open days, etc.) and representatives of different professions who are acquaintances of the learners (see Figure 3). The information about science and education establishments, which is received during study fairs or from mass media companies, is important to almost one fourth of the respondents. One fifth of the learners were encouraged to choose exact science subjects by teachers of the subjects, classmates and friends. Although in order to help school leavers in choosing a future professional career the Ministry of Education and Science has created different data registers where the information on different professions and study programmes of higher education institutions training them is presented, and in schools the positions of profession consultants have been established, however, these measures make probably the least impact on the learners' decisions.

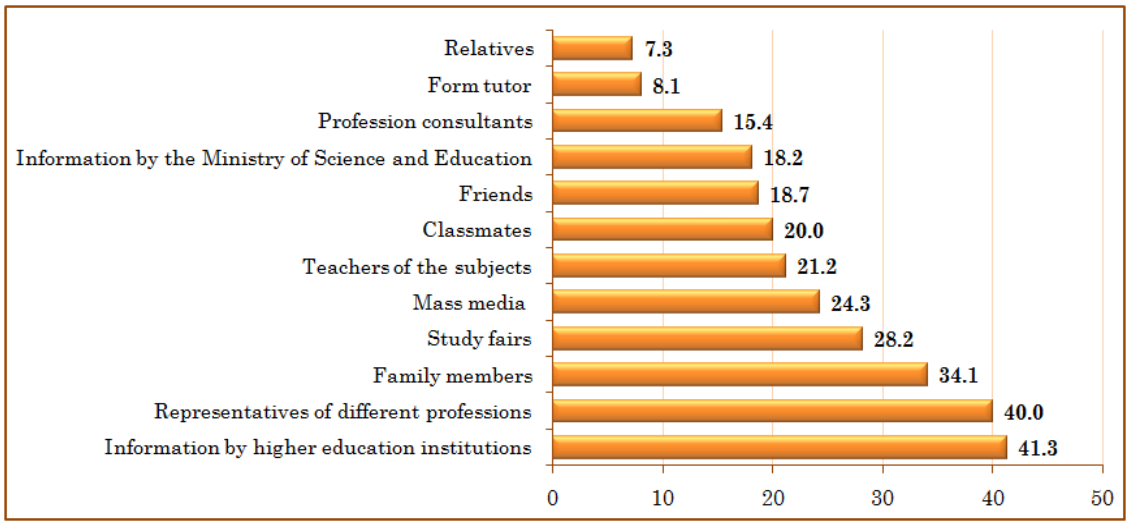

Figure 3 Factors Predetermining the Choice of Exact Science Subjects (%, N = 1,019)

4.3 Self-reflection of the Choice of the Subjects

In the examination of the learners' reflection on choosing the exact science subjects and their learning levels, it was established that almost 85% of them pointed out that they had chosen an appropriate Mathematics learning level. About 77% of the respondents were satisfied with the choice of the level of learning Information Technology and Physics, while about 75% — Chemistry.

More than three quarters of the respondents stated that they had chosen appropriate levels of learning the exact science subjects (see Figure 4). Moreover, it was noticed that this choice is not only appropriate but also useful to the learners (x^2 = 179.5; df = 4; p < .0001). Such a provision dominates in particular among the learners

who chose a higher subject learning level (x^2 fluctuates from 11.2 to 69.6; df = 4; p < .0001).

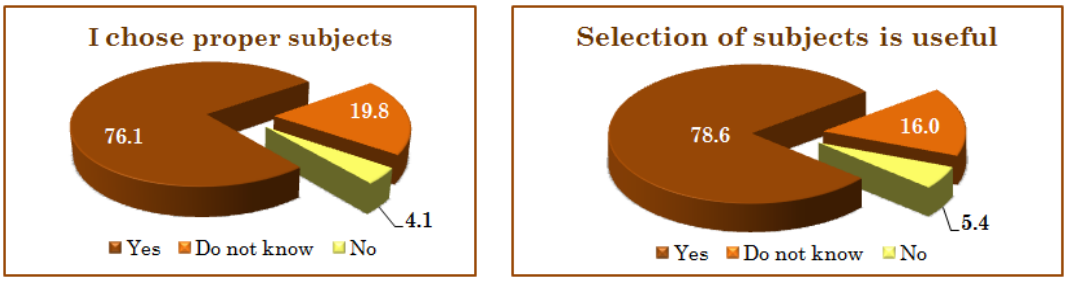

Figure 4 Self-Assessment of the Choice of the Exact Science Subjects (%, N = 1,019)

As a rule, the learners who are satisfied with their choice of the exact science subjects plan to take state maturity examinations of these subjects (x^2 fluctuates from 10.1 to 26.7; df = 2; p < .01). Moreover, the respondents satisfied with their choice of the subject more often stated that they like, are interested and are good at Mathematics, have a good teacher, while the subject itself is important for their future profession (x^2 fluctuates from 19 to 37.5; df = 2; p < .0001). Similar trends are observed also speaking about other subjects of exact sciences.

However, more than one fifth of the learners are dissatisfied with their choice and would like to change it, but such possibilities for them are rather limited. If at the beginning of the 11th learning year a learner may choose a new subject, subject module or refuse a subject, subject module or change the level of learning the subject, it is not recommended to make changes at the second half of the 11th learning year and in the 12th learning year.

More than 85% of the respondents would choose at least one more subject in case a maximum number of 32 weekly lessons were not limited (see Figure 5). Such an attitude much more frequently was expressed by those learners who are dissatisfied with their choice of the subjects (x^2 = 26.4; df = 4; p < .0001). This demonstrated that the learners want to learn more diverse subjects than they are offered and to acquire a wider spectrum of competences required for the future professional activity.

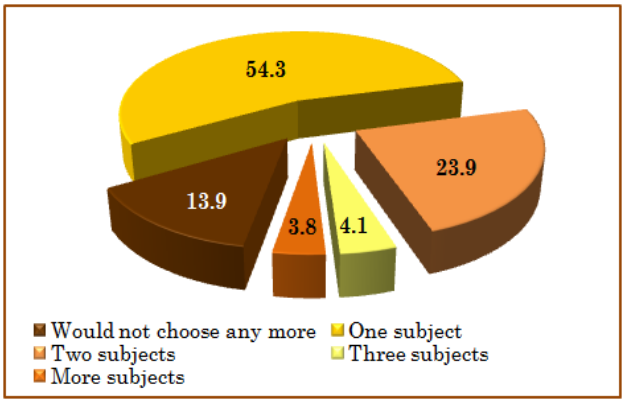

Figure 5 How Many Subjects Would Learners Choose if There Were Possibilities? (%, N = 1,019)

4.4 Links between the Future Career and the Choice of the Exact Science Subjects

Based on the data of Statistics Lithuania and the Association of the Lithuanian Higher Education Institutions for joint entrance (LAMA BPO), in recent years more than 60% of school leavers of the country choose further studies at the Lithuanian higher education institutions. From 2010 in our country the entrance takes place to the

following studies in the higher education institutions: social, humanities, physical, technology, biomedical sciences, arts and teacher training. The higher education institutions offer about 1,400 study programmes.

The data of the research carried out shows (see Figure 6) that most popular are the studies of social sciences. The lowest number of the respondents plans to choose the teacher training study programmes. Such a tendency of the teacher's profession unpopularity is inspired by a lowered prestige of this profession in the society and fear of the youth not to find a job due to the decreasing number of the learners and schools.

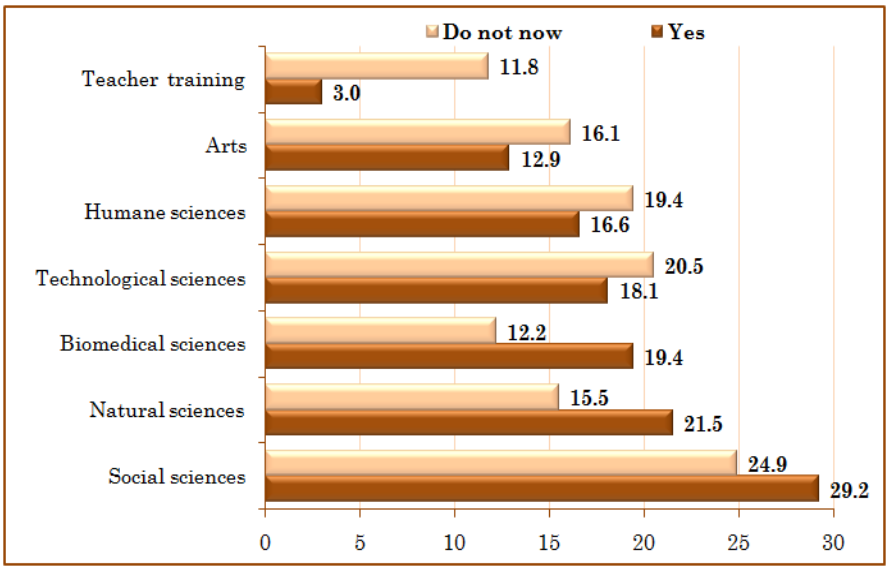

Figure 6 Further Studies Planned by the Learners (%, N = 1,019)

Although the social science studies are the most popular ones; however, it should be noted that much more frequently they are chosen by the learners who learn the exact science subjects at a lower level. Those who chose a basic Mathematics learning level more often plan to enter the study programmes of Humanities, Arts and Teacher Training, while those having chosen a higher level — the study programmes of physical sciences (x^2 fluctuates from 6.9 to 34.7; df = 2; $p < .05$). Those learning Information Technology and Physics at a basic level would more often choose the studies of humanities and social sciences as well as biomedical studies, those learning at a higher level – studies of physical and technological sciences (x^2 fluctuates from 9.9 to 101.3 df = 2; $p < .01$), while those learning Chemistry at a higher level would be more inclined to choose the studies of biomedicine ($x^2 = 47.3$; df = 2; $p < .0001$).

The learners who study Information Technology and Physics additionally not only plan to take state maturity examinations of this subject but also intend to link their future career with physical and technological sciences (x^2 fluctuates from 14.4 to 139.1; df = 2; $p < .0001$). Whereas those learning Mathematics additionally also more often plan to take the examination of this subject; however, they do not link their future career with the fields, where the knowledge and abilities of Mathematics would be required ($x^2 = 63.2$; df = 2; $p < .0001$). This means that Mathematics is additionally learnt only in order to better pass the maturity examination of the subject.

The research results show that the respondents have sufficient information on what knowledge and abilities they will need when studying at the Lithuanian higher education institutions. For example, Mathematics, Information Technology and Physics, in the learners' opinion, are important in choosing the studies of physical and technological sciences (x^2 fluctuates from 30.4 to 206.9; df = 2; $p < .0001$), while the Information Technology

is also important in studying social sciences (x^2 =20.6; df = 2; p < .0001). However, willing to study the study programmes of biomedicine, in the respondents' opinion, the knowledge and abilities of none of the exact sciences, in particular Chemistry, will be required (x^2 fluctuates from 7.7 to 304.7; df = 2; p < .001). This demonstrates the shortcomings of not only the system of consulting on the learners' career and profession but also the publication of the studies in higher education institutions. Both profession consultants and representatives of public relations in higher education institutions should give more attention not only to promotion of study programmes and attractiveness of the future career but also introduction of the competences required for further studies to the learners. This should be done at least in the 9th–10th learning years, before the learners choose the subjects and their learning levels. Moreover, it should be noted that the learners intending to choose the studies of physical, biomedical and technological studies demonstrate not the best results of the exact science subjects, in particular of Mathematics (x^2 fluctuates from 7.7 to 61.9; df = 2; p < 0.05 and p < 0.01). Other authors also discuss the decreasing level of the learners' knowledge and abilities of Mathematics and other exact science subjects by analysing the situation in higher education institutions (Novikienė & Matiukaitė, 2009; Saldauskienė, 2008).

As it has already been mentioned, there are not many available researches in this field; thus, the results of this research cannot fully define the current situation of choosing the exact science subjects and their learning levels and its impact on the future professional learners' career. This requires a more exhaustive and detailed examination of the majority of the problems mentioned in this article.

5. Conclusions and Recommendations

(1) A great share of the learners, in particular of those living in cities and towns, chooses a higher Mathematics learning level. Physics and Chemistry are chosen by especially few learners. This is a matter of concern, as recently, as the entrance to the study programmes of the exact sciences and technological profile has been increased, there may be a lack of the learners who are properly prepared to study them.

(2) Learners in essence are positive about the possibility to choose the subjects and their levels; however, at least one fifth, in case of a possibility, would change the subjects chosen or would like to learn additionally at least one or more subjects.

(3) Out of all the subjects of exact sciences the learners are most positive about Mathematics, what cannot be said about other subjects of exact sciences. Moreover, almost 80% of the learners learn the subject at a higher level, at least one third also learn additionally, while the major share plan to take state maturity Mathematics examination. A great share of the learners thinks they have good Mathematics teachers. Whereas the learners having good teachers of Information Technology, Physics and Chemistry less often chose a higher level of learning these subjects.

The greatest impact on choosing the subjects of exact sciences is made by family members, relatives, representatives of different professions who are acquaintances of the learners and the information by higher education institutions. However, in the opinion of the authors, the information designed for the learners of higher education institutions, study fairs should be focused not only on the presentation of the university study programmes and future career perspectives but also on orientation of the learners of basic schools to purposefully choose the subjects and their learning levels.

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