

# The Influence of Social Conditionality on the Results in Computer Science Test of Graduates

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**Abstract.** The paper presents graduates results in computer science testing according to their dependence from students' gender, family socioeconomic status, and the type of prosperity of the locality of the school in Lithuania. It was found that the gender of the graduate does not affect the results in computer science test. However, the girls who chooses to take the Computer Science Matura Exam make up only 1/5 of all graduates. Meanwhile, the socioeconomic status of the student's family, the way of travel to and from school and the type of locality prosperity systematically does affect the results of computer science test of graduates. The entire population of Lithuanian general education school graduates (N = 2208) who chose to take the Computer Science Matura Exam in 2023 was investigated. Testing was administered centrally using a standardized test. As a hypothesis the insights were formulated on how to improve the computer science didactic system in the country's general education sector. On the basis of empirical data, conclusions and specific recommendations were formulated to improve the system of didactics of informatics in the field of general education in the country.

**Keywords:** Computer Science test; Matura exam; testing graduates; gender; social conditions.

## 1. Introduction

After the end of the COVID pandemic, in many countries aim to strengthen the public's readiness to live in the digital world and the importance of digital competences expansion are emphasizing (European Commission, 2020). All this led to a greater focus on computer science and enforced, while still in school, to take care of the basic abilities of graduates necessary to enter this field of science. However, there is no unite consensus on the content of the competences needed to be developed. The European Commission suggests applying the Digital Competence (DigComp) framework (European Commission, 2022) while the UNESCO suggests using the concept of Digital Literacy which

includes a computer literacy, ICT literacy, information literacy, and a media literacy (Law *et al.*, 2018). It's an ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship.

DigComp covers five areas of computer science competencies: Information and data literacy, Communication and collaboration, Digital content creation, and Problem solving. UNESCO proposes to supplement it with two additional components of computer science field competencies: Devices and software operations, and Career-related competences.

The *IEA International Computer and Information Literacy Study (ICILS) 2018* is using the concept of Computer and information literacy (an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society) (Fraillon *et al.*, 2018). The Informatics for All coalition suggests using the Informatics Reference Framework for School (Caspersen *et al.*, 2022) which emphasizes the importance of the informatics discipline and distinguishes the following computer science topics: Data and information, Algorithms, Programming, Computing, Systems, Networks and communication, Human computer interaction, Design and development, Digital creativity, Modelling and simulation, Privacy, safety and security, Responsibility and empowerment. Also, a number of countries seek broader 'computational thinking' goals (Bocconi *et al.*, 2022) in order to fulfill continuously growing expectations in computer science field. While the definitions' contents are not identical, they partially overlap and emphasize the same areas. The Informatics for All coalition observed (Caspersen *et al.*, 2022) that the DigComp model is more focused on digital competences, primarily addressing the operational aspects of adequate preparation for a digital society, while, the Informatics Reference Framework for Schools specifically focuses on the discipline of informatics and the knowledge it provides.

In the general education systems of many European countries, a separate subject as a computer science, computing, informatics and information technologies is already developed purposefully to prepare children for the digital society (Eurydice, 2023a).

At the Lithuanian general education school, students at the basic level must study information technology, and in the secondary education they can choose to study information technology in a general and advanced course. The subject of information technology was renamed to informatics from 1st of September of 2023. Total 70 hours duration course includes: Layout of text documents, Numerical information processing with a calculator, Preparation of presentations and Safe and legal use of information and the Internet. Students who have chosen an extended 140-hour duration course additionally chooses one of the three modules offered in this advanced course. These are: 1) Programming; 2) Creation and management of databases; 3) Electronic publications. The training has an applied commencement, focusing on the development of practical skills and knowledge in computer science. It should be noted that the content of the Lithuanian information technology subject covers both DigComp/digital literacy and the topics offered in the Informatics Reference Framework for School model (see Table 1).

Table 1  
 Comparison of Lithuanian Computer Science content with Informatics Reference Framework for Schools and DigComp

Lithuanian Computer Science curriculum	Informatics Reference Framework for School	DigComp
Layout of text documents; Numerical information processing with a calculator; Preparation of presentations; Creation and management of databases; Electronic publications	Digital creativity	Digital content creation
Safe and legal use of information and the Internet	Privacy, safety and security; Responsibility and empowerment; Networks and communication; Data and information	Safety; Problem solving; Communication and collaboration; Information and data literacy
Programming	Algorithms; Programming; Modelling and simulation; Computing Systems; Human computer interaction; Design and development	Digital content creation

Assessment of student’s competence in computer science can be performed by using various social science research methods: observation, interview, survey, testing, content analysis, fact analysis, competence portfolio, performance portfolio, reflection diary (online blog), etc. More emphasis is placed on the summative assessment executed by the testing method. It includes such risks as the subjectivity of the assessed individual, which is caused by weak motivation during the assessment of the identified psychological state. Additionally, there is a greater focus on theoretical knowledge than practical skills. Such assessment is related to practicality (quick use, inexpensive, simple and relatively informative questions) and a wide range of respondents (Jucevičienė and Brazdeikis, 2012).

The most widely discussed digital literacy testing initiative is European Computer Driving License (ECDL) created by the Association of European Computer Societies (ECDL/ICDL Foundation) in 1993 (in Lithuania first time introduced in 2000), later transformed into the International Certification of Digital Literacy (ICDL)<sup>1</sup>. The certificate is recognized in more than 170 countries around the world, more than 17 million people have been certified. Testing is carried out on an online platform under the supervision of employees of an authorized center. After passing the tests of 4 modules (Basic Concepts of Information Technology, Computer Use and File Management, Word Management, Information Communication), an ECDL basics certificate is issued, and after passing the seven-module tests (additionally Calculator, Database, Presentation Preparation), a full certificate is awarded. The ICDL Foundation is quite active

<sup>1</sup> [www.icdleurope.org](http://www.icdleurope.org)

in the digital literacy market: it has helped the European Commission to prepare the DigComp construct<sup>2</sup>, conducts various studies (e.g. a digital literacy survey that reveals that people have self-esteem (e.g. Europass CV) tends to overestimate oneself (ICDL Foundation, 2018). Recently the popularity of the ECDL/ICDL certificate in Lithuania and other European countries is decreasing, although it is still developing quite actively on the Asian and African continent. Often, such trends are associated with its increasingly less relevance in the market. The certificate demonstrates more theoretical knowledge than specific abilities and the acquisition of their alternatives (e.g. Microsoft Office Specialist).

Another case of testing can be considered the Bebras challenge for students, which was started in Lithuania in 2004<sup>3</sup>. Students during the competition perform various tasks presented in the online system. Other countries (78, 2023 – 87) are actively joining this initiative, the number of participants is growing (in 2022 – 53,975, 2023 – 55223) participants in Lithuania) (Dagiene *et al.*, 2023). The Bebras seeks to stimulate students to be interested in computer science, computer thinking. An analysis of the Bebras tasks revealed that the tasks are dominated by algorithms and data visualizations, which make up 75–90% of the tasks. Previous studies demonstrated that Students manage to solve a part of the Bebras tasks before receiving any training on computational thinking. It reflects their readiness to learn through daily activities (Izu *et al.*, 2017). It is accepted that the execution of the Bebras challenge has a positive effect on computational thinking. However, the competitive character of the Bebras challenge leads students to focus more on memorizing decisions than on logical, critical thinking<sup>4</sup>.

In many countries, digital competence assessment is carried out in the national tests/exams of general education schools (Eurydice, 2023b). At the secondary level of education, information technology assessment is carried out in a dozen countries, but only in Malta, and Romania it is mandatory. In twelve education systems, digital competence is assessed as optional (as is learning) and therefore only a part of students chooses it. France provides an opportunity to confirm the digital skills of students who have completed secondary education with the PIX certificate (Eurydice, 2023b).

In Lithuania, the Computer Science Matura Exam is conducted according to a specially prepared Exam program, the formal goals of which are not only to check and evaluate the graduates learning achievements according to the general program, but also to help the graduates to self-assess the readiness for the programmer's professional studies.

School students and teachers often give more respect to exams than to the process of learning. Besides, it is better for pupils to have more choice for choosing exams. In 1995, the informatics maturity exam was developed. Informatics as a separate subject was taught for many years in Lithuanian schools thus to establish the maturity exam in informatics was a natural process. Discussion on informatics exams has been presented in (Blonskis and Dagiene, 2008).

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<sup>2</sup> <https://icdl.org/digcomp/>

<sup>3</sup> History | [www.bebbras.org](http://www.bebbras.org)

<sup>4</sup> <https://www.lumiere-education.com/post/bebras-challenge-10-things-you-need-to-know-to-win>

The tasks of the Computer Science Matura Exam organized in Lithuania are designed in four areas: Safe and legal use of information and the internet, editing of text documents, processing of calculus information with a spreadsheet, and Programming. Part of the thematic blocks of the curriculum is not included in the system of exam tasks. In the exam assignment, 50% of the assignment corresponds to the general course of the Computer Science, 50% – to the topic of the advanced course programming module. The exam is usually chosen by graduates who have taken an advanced Computer Science course with a programming module. However, those graduates who have taken only the general course of the subject, without a programming module, are also allowed to take the freely elective exam. It is clear that such a framework of the exam and the structure of tasks motivates graduates to choose an exam and achieve high results only for those children who de facto have more profound knowledge and are especially interested in programming.

Bearing in mind the importance of readiness in computer science, in a modern knowledge society, the question arises, does such a specific discrepancy between the curriculum and the exam tasks, focused essentially on an elite subgroup of graduates, not violate the principles of accessibility to education and equal opportunities? However, this aspect goes beyond this study, which focuses on the social conditioning of learning achievements, as well as gender differences in the context of school computer science.

Statistical data of the Matura Exam in the subject of Computer Science have been collected and archived in the country since 2006<sup>5</sup>. It is necessary to state a circumstance that is not entirely favorable from the point of view of education policy and the practice of teaching computer science. The aforementioned array of data has so far never become the object of constant attention and more consistent research of scientists. Therefore, first of all, it makes sense to study the exam data in terms of the quality of educational diagnostics. This is a standard check for validity and reliability of the task system, and analysis of the ICC – Item Characteristic Curve, and of the received empirical distributions. Second, having become convinced of the quality of the collected measurement data, it makes sense to switch to variables explaining the differences in the results in computer science test in the graduates' population and specifically in its subgroups. Here discussing the differences in computer science learning achievements in groups between boys and girls and between graduates from metropolitan areas and poorly urbanized areas, etc. Thinking hypothetically, those variables can be not only social but also psychological, e.g., the motivation for mentees' learning, cognitive interest, didactic auto-conception. Also, educational factors such as: the dominant methods of teaching and learning computer science, the provision of the computer science cabinet with teaching aids, technologies, the readiness and competence of teachers. Systematically generated information of this kind would be useful in improving the teaching and learning of the subject of computer science.

Studying the various variables that systematically affect the level of learning achievements, a lot of work has already been done in science at the moment (Honicke

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<sup>5</sup> National Education Agency – » Results (smm.1t)

*et al.*, 2023; Wang *et al.*, 2023; Strello *et al.*, 2021; Steinmayr *et al.*, 2019). This applies to the main subjects of teaching mathematics, natural sciences, reading, writing, as well as, in part, school computer science. In this respect, the ongoing international comparative studies on learning achievements organized by the IEA and the OECD, such as TIMSS, PISA, PIRLS, deserve special attention. The above-mentioned large-scale studies are characterized by huge and high-quality national samples, control of measurements performed, a unified, methodologically accurate system of educational tests and questionnaires, and an adequate strategy for statistical processing of data. Of course, it has to be admitted that in these studies, students' knowledge of computer science is not tested. The interface with computer science is in that traditional paper-pencil print tests have recently been abandoned and there was a shift to online testing.

However, the statistical regularities found in the above studies about the social determination of learning achievements are quite universal. As will be shown, they repeat both in the context of school computer science in general, and in the results of this study. It is known that learning achievements are affected by a very large number of factors of different nature: the personality of the student, health, family, school, lesson, teacher, etc. Here it is especially noteworthy that it is the social determinants of learning achievements that are relatively the strongest. The impact of social determinants is often even stronger than internal psychological factors (student's motivation, interest, educational auto-concept, etc.) and educational factors (dominant teaching and learning methods, educational environments, etc.). The social determinants in the studies are tried to be reflected through various variables, measured with the help of questionnaires. These are:

- a) A type of school.
- b) The socio-economic status of the family.
- c) Rural-urban disparities.
- d) Racial differences.
- e) The status of the migrant versus local resident.

It should be noted that in Lithuania, as in many other countries, the social determinants of learning achievements are expressed relatively significantly. This unfavorable circumstance is also characteristic of the developed countries of Western Europe. Social determinants are much less pronounced in Estonia and Finland, which indicates the exceptional achievements of these countries in the field of general education (Crato, 2021). The question of the exceptional success of the above countries in the field of education in modern science remains unanswered. This actualizes the study of the social determinants of learning achievements. The modern state is ideally obliged to consistently strive for equal opportunities and well-being to be guaranteed to all children, regardless of origin, social status, place of residence. Absolute equality possibly objectively can never be achieved, but using research on educational indicators, those inequalities can be diagnosed in a timely manner and then to mitigate them through social and educational policies. In regard to this the regularities of the ranking of countries are quite strongly expressed. Some countries are able relatively to implement this aspiration, while others do not succeed very well. The regularities of the rankings so far are only recognizable

at the descriptive level. The significant contrasts between the achievements of countries and ratings structure and its in-depth factors and regularities at this moment in science have not yet been cognized and explained<sup>6</sup>.

Factors of social inequality also include gender differences, which occur in different areas of learning achievement. However, it is legitimate to say that the educational studies of gender differences have long formed an autonomous trend of gender studies (Verbree *et al.*, 2023; Rosén *et al.*, 2022).

The results of numerous studies on gender differences in the field of learning achievement are controversial. In some studies, differences between genders are found (Mullis *et al.*, 2000), in others they are not detected (Hadjar *et al.*, 2014). Some studies show a tendency for boys to become losers in education (Sjøberg, 2020). They disclose that in the highest achievements' subgroups for mathematics, writing and languages the girls make up 60–70%, while in the general population the gender ratio is 50:50 percent. Accordingly, in the lowest subgroup of achievements, 60–70% are boys (Merkys *et al.* in Press). However, come to the fore some of the systematic repetitions of patterns about gender differences. Girls usually perform better in reading and writing and the boys in mathematics and science (Steinmann *et al.*, 2023; Oberleiter *et al.*, 2023; Schwippert *et al.*, 2019; Meinck, Brese, 2019; Grebe, 2013). There is currently a consensus in science that the likely relative backwardness of girls in mathematics, science and technology stems not from the immanent differences between the genders and their objective capabilities, but is primarily due to conservative sociocultural inertia. Of particular note are the flawed social stereotypes (Milic, Simeunovic, 2023; Mejía *et al.*, 2021; Starr, Simpkins, 2021; Breda *et al.*, 2020) that still exist. With the framework of educational environments that empower girls in the family and at school, those supposed immanent differences disappear.

The aforementioned arguments actualize an exploratory study initiation and the search for data-based answers to a particular question. The main research question of this study is:

**Do gender and social variables affect the results in computer science test measured by standardized tests?**

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<sup>6</sup> All explanations are given at the level of hypotheses. The relative success of the Scandinavian countries is sometimes explained by a socially sensitive, solidarity-permeated, non-competitive, empowering culture of society and school. The relative success of the countries of the Far East is tried to be explained by the Confucian ethics of labor and the performance of social roles. It is very difficult to explain the German paradox. In 1996, the country experienced the “TIMSS shock”, and in 2001 the “PISA” shock. A developed industrial country with a high educational culture turned out to be very average in international comparisons, at best climbing only to the middle of the ranking of countries. Regional and school-type contrasts in the aforementioned country are also strongly expressed. In the face of the aforementioned “shock”, Germany, like no other country, mobilized political will, financial, scientific and organizational resources to overcome the conditional backwardness in the ratings. Despite several decades of focused efforts, the situation in Germany is not significantly improving. The scientific answer to why this is the case is also lacking at this point.

## 2. Related Works

The question of how do social variables and gender inequality manifest themselves in the context of school computer science deserves special attention? It is becoming clear that the discussed general statistical regularities, which are determined between social factors and the estimates of educational tests, tend to manifest themselves systematically and in the context of school computer science.

For example, a 2015 study by scientists in Chile found a close relationship between the economic, social, cultural status of the family and the digital skills of students measured by tests (Claro *et al.*, 2015).

Data from the International Computer and Information Literacy Survey (ICILS) (2013, 2018, 2023) consistently show a significant positive relationship between students' socio-economic status (SES) and their computer information literacy (CIL) and computational thinking (CT) skills across all participating countries. This difference is evident across a range of SES measures, with students from higher SES strata consistently outperforming their lower SES peers (Fraillon, J., 2024). Lithuania participated in the ICILS 2013 study, which examined the impact of parental education, parental responsibilities, and home library size on student achievement. Students with highly educated parents outperformed students with less educated parents by an average of 72 points, and in Lithuania by 63 points (the average student achievement in the study was – 500 points). Moreover, higher parental responsibilities were associated with higher student CIL scores: the average difference in CIL scores was 54 points, compared to 45 points in Lithuania. Finally, the study found a positive relationship between the size of the home library and the student's CIL score. Students with 100 or more books at home outperformed those with 10 or fewer books by an average of 73 points globally, and by 63 points in Lithuania (ITC, 2014).

Analogous empirical findings about the relationship of students' digital competencies to the sociocultural indicators of the student's family were published by scientists of various countries (Hatlevik *et al.*, 2015; Wei *et al.*, 2022; Scherer, Siddiq, 2019; Heinz, 2016; Aesaert, Braak, 2015; Martins, Wangenheim, 2024). The wide geographical variety of studies carried out and their scientific findings testifies the universality of the statistical dependencies found in terms of space and time. Rises' the likelihood that systematically detected regularity of relation is real and objective. In turn, the likelihood that the regularities detected are merely a statistical artifact or bias effect arising from the ad hoc context of the local study minimizes. It means that also the less expected sample dysfunctions which are typical for fragmentary studies, insufficiently valid measuring tools, local specificity uncharacteristic for the general population, etc.

A separate noteworthy discourse is Computer Science competencies and gender. If talking about the labor market for information communication technology (ICT) specialists, then the situation here remains clearly discriminatory. According to Eurostat data for 2023, women make up only 19.4% of working ICT specialists (Eurostat, 2024). However, in empirical studies that measure learning achievement in the field of school informatics, fundamental, discrimination indicating differences between the genders are not recorded. In this respect, the results of ICILS speak especially eloquently.



For example, in 2013, in all the countries studied, girls even tended to outperform boys in computer and information literacy (CIL) (IEA, 2013). The average CIL score of girls was statistically significantly higher than that of boys in all countries except Turkey and Thailand. The average score of girls in the ICILS 2013 survey was 509 points, and that of boys was 491 points. The difference was 18 points. In Lithuania, the difference was 17 points (ITC, 2014). The researchers (Punter *et al.*, 2017) in detail studied 2013 ICILS differences between girls and boys. It was stated that gender differences are found not by holistic assessment of competences, but by individual specific constructs of “computer and information literacy”. These constructs include three components: 1) Technical Functionality; 2) Evaluating and Reflecting on Information; and 3) Sharing or Communicating Information. It has been observed that boys lag slightly behind girls in terms of competencies such as evaluating and sharing information, but demonstrating technical skills higher than that of a girl

The ICILS 2018 and 2023 data also show that there is a gender gap in achievement in computer information literacy (CIL) and computational thinking (CT). In 2018, girls scored an average of 505 points on CIL, while boys scored 488. This trend continued in 2023, with girls outperforming boys on CIL in many countries. This finding is supported by national surveys from Australia (NAP-ICT) and the United States (NAEP-TEL), which also showed higher CIL scores for secondary school students (Fraillon (2024)). Conversely, in 2018, boys outperformed girls on CT, scoring an average of 502 points, compared to 498 for girls. This trend continued in 2023, with boys scoring 485 points and girls scoring 482 points, although the difference was relatively small. Fraillon (2019) suggests that these different gender patterns in CIL and CT may be related to differences in students’ use and attitudes towards ICT.

In the Bebras challenge the differences between boys and girls were usually small, but when performing some tasks related to spatial skills, small gender differences (in favor of boys) were observed in all age groups (Izu *et al.*, 2017).

In the 2018 ICILS study, girls were slightly ahead of boys, scoring an average of 505 when boys 488 scale points (Fraillon *et al.*, 2018). On average, however, boys did better than girls in the “computer-based thinking” section, scoring 502 points on the “computer-based thinking” scale, compared to 498 girls. The differences found are minimal. As is known, in IEA and OECD studies, 500 points usually correspond to the average of rationing in all countries, with a standard deviation of 100 points. Adhering to Cohen’s effective size assessing recommendations, differences in group averages below 1/5 of the standard deviation are considered minor and it is even advisable not to interpret them (Lovakov & Agadullina, 2021). The gender differences that are detected by such a diagnostic construct as the cognitive interest of students in relation to information technology are worthy of attention. It is trivial that the curiosity of boys in relation to IT is expressed relatively more strongly than peers’ girls. It can be interpreted as an inertia of the manifestation of social stereotypes, which actualizes the creation of educational environments that are friendly to the girls and enables them.

The researchers (Bocconi *et al.*, 2022) who examined the differences in computer thinking assessment between girls and boys summed up that there is no clearly unambiguous position. Some studies have not identified a significant gender imbalance. There are

those who believe that certain gender differences are determined by certain approaches to the development of information technology skills, possibly related to specific abilities activated by certain tasks or different gender-related speed of development, and stages can in this case be the main determining factor.

### 3. Design

#### 3.1. Indicators

The study's dependent variable (see Table 2) is the student's competencies developed by the information technology subject, measured by a standardized test. From a thematic point of view, the computer science test covered the following areas/topics of the subject of information technology:

- I. Safe and legal use of information and the Internet (10 points, 7 questions).
- II. Text editing using document editing software (20 points, 7 tasks).
- III. Processing of numerical information by a spreadsheet (20 points, 4 tasks).
- IV. Programming (50 points, 2 tasks).

The test consisted of a total of 20 tasks. The duration of testing is 3 hours. It is about the Computer Science Matura Exam, which was centrally taken in the country in 2023 by all graduates who chose the relevant exam. The tasks of the national test are prepared centrally, their content is kept secret till the exam. The files of the completed test are sent for evaluation to the central headquarters and there the results are evaluated by at least two experts. In all regions and municipalities, testing is carried out at one and the same time. In contrast to the exams in mathematics and the Lithuanian language, the Computer Science Matura Exam is not mandatory<sup>7</sup>, it is freely chosen. It is chosen by those graduates who are preparing for appropriate studies or are confident of their knowledge of this subject. For example, in 2023, about 10% of students from the general population of graduates chose to take the Matura Exam (test) in Computer Science. Meanwhile, 62 percent chose to take the Mathematics State Matura Exam and 75 percent of the total graduate population took the Lithuanian Language and Literature State Matura Exam.

The verification of knowledge of all subjects during the centralized Matura Exam in Lithuania is based on standardized tests. When compiling test kits, the methodological concept of TIMSS-PISA-PIRLS studies is considered as a benchmark (Hernández et al, 2021). Its features are as follows: 1) all the main topics of the school subject are included in the test; 2) there are many tasks; 3) tasks of different difficulty; 4) a lot of time is spent on testing, well beyond the time of the traditional lesson. Previous studies have shown that the Matura Exam central system is based on test kits, which are

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<sup>7</sup> State Matura examinations in Mathematics and Lithuanian Language and Literature are mandatory for those graduates who are going to apply for a free place of study at a university or college. Graduates who do not claim a state-sponsored, free study place by competition, usually take not a state, but a school leaving examination.

Table 2  
Independent and dependent variable

Independent variable	Dependent variable
1) The gender of the graduate.	The data of standardized testing of all Lithuanian graduates (N = 2208), who in 2023 chose to take the Computer Science Matura Exam. The test consisted of a total of 20 tasks: I. Safe and legal use of information and the Internet (10 points, 7 questions). II. Text editing using document editing software (20 points, 7 tasks). III. Processing of numerical information by a spreadsheet (20 points, 4 tasks). IV. Programming (50 points, 2 tasks).
2) The socioeconomic status of the family: • The graduate receives or not receive free school meals. • Receives or does not receive social assistance.	
3) The way of travel to and from school.	
4) The type of well-being of the area where the school operates.	

characterized by high psychometric quality. Thus, the data can be used not only for the administration of education, but also for scientific purposes (Merkys *et al.*, 2024).

An independent research variable (see Table 2) is characterized by indicators such as: 1) the gender of the graduate; 2) the socioeconomic status of the family; 3) the way of travel to and from school; 4) the type of well-being of the area where the school operates.

Due to data protection standards, it becomes difficult to have complete data about the family in scientific research. In this study, there were two reliable variables measured in national educational statistics. These are: 1) the graduate receives or not receive free school meals and 2) receives or does not receive social assistance. This variable is defined by a 4-stage categoric variable: a) receives neither meals nor support; (b) receives only meals; (c) receives only support; (d) receives both meals and support. Graduate who receives two forms of support represent the most socially vulnerable families.

Third variable is the way a graduate travel, i.e. how a graduate being a student reaches school every day from home and returns from it. The nominal variable has five categories that classify the way of travel: (a) by a school transport; (b) by a yellow bus; (c) by a shuttle bus; (d) by other transport and (e) by a family’s transport. The variable is particularly eloquent from a social point of view, in the sense that the ability and motivation of the family to take the child to school and back every day by a private family car marks its belonging to the middle social class at least. For many families, especially in the rural regions, this poses a significant challenge.

The category “yellow bus” means that the vehicle was acquired with the funds of the central government and handed to the school. The school transport means that the vehicle was acquired with the funds of the local municipality. Both types of vehicles do not visually differ. However, there is a social subtext. A chance of receiving a yellow bus from the central government is held by those schools with worse social indicators and the accessibility of the school to students is difficult.

The local municipality, if it is motivated and resources, can donate a school bus to any of its schools. Split of the categories yellow bus and school transport made it pos-

sible to test the hypothesis does that remoteness and relatively greater social detachment affects student achievement in computer science.

The fourth variable that characterizes the well-being of the area has its own compelling logic from the primary data. There are 60 administrative-territorial units in Lithuania named the municipalities. This list has been classified into 7 types (see Table 3). This is a categorical variable structured based on the traditional sociological differences of urban rural. In the sociocultural conditions of Lithuania, prosperity is distributed unevenly in the regions. Most welfare indicators are much more favorable in large, urbanized municipalities, than in remote, poorly urbanized municipalities in the periphery.

### 3.2. *Data*

In this study total census data was used. The data of standardized testing of all Lithuanian graduates (N = 2208), who in 2023 chose to take the Computer Science Matura Exam, were selected for the study. Testing (and the exam) is based on a criterion assessment. The minimum threshold for passing points in the exam is set and approved by the Matura Examination Assessment Committee. Graduates who have reached the minimum threshold of passing points on the exam are considered to have passed the exam.

### 3.3. *Research Questions*

The arguments presented in the “Introduction” and “Design” sections precisely determined the main research questions as well as the general logic of finding answers to them. 1. Are the empirical data that the researchers took from the government statistics archive suitable for analysis? What are these primary data? This is verified by exploratory analysis. 2. Are gender effects manifested (or not manifested) among school graduates in terms of educational achievements in school computer science? 3. Do social environmental factors manifested (or not manifested) among school graduates in terms of educational achievements in school computer science?

## 4. Findings

### 4.1. *Exploratory Analysis*

Initially, it was appropriate to conduct an exploratory analysis of total census data. The result of the exploration of the dependent variable is presented in Fig. 1.

The empirical distribution of test estimates deviates significantly from the theoretical normal distribution. There are at least two consequences: 1) must be used nonparametric methods, 2) from the configuration of the empirical curve can be hypothetically judged about the phenomenon being measured. A curve of the flat letter “U” was obtained. The curve resembles a flat, right-leaning bowl. The modal value of the distribution approach-

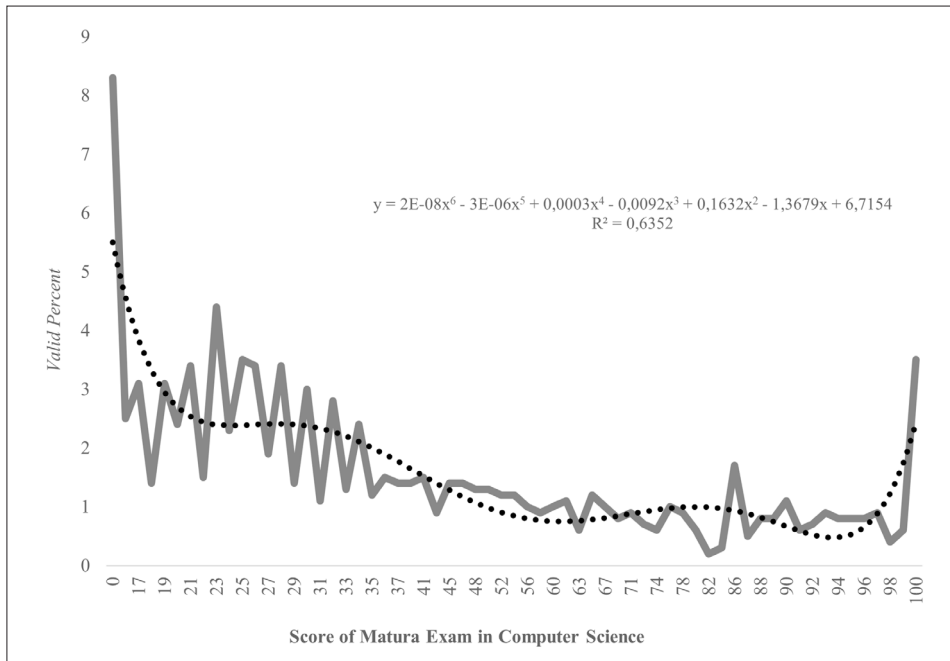


Fig. 1. Empiric distribution of the scores of the computer science test from 0 to 100 points. The dotted line denotes the polynomial curve of the 6th degree.  $N = 2208$ .

es the score “0”. Which means that the exam has not been passed. The non-retention quota is 8.3%. The curve takes the form of a monotonously descending slightly undulating function.

At a hundred points which constitute the possible maximum score of the test the empirical curve again suddenly jumps to the top. This exceptional test result belongs to 3.5% of the total of graduates who have taken this test. In the presence of this type of distribution, the average is a low-eloquent, and the scattering of the measured feature is naturally high. There is no doubt that tested graduates who scored 100 points (a maximum score) in this case are the most gifted graduates of the information technology subject. Probably, these are future computer science students, and in the long run, market leaders and talents in programming, as well as IT engineering services.

Discovered fact raises the question, is the computer science test valid from a psychometric point of view? Such verification is usually performed by correlating test estimates with other conceptually related measurement constructs. Table 3 shows the correlation matrix. Due to the large sample, all the coefficients in the matrix satisfy the  $p < 0.001$  significance criterion.

The resulting correlation matrix does not meet the requirements for the multitrait-multimethod concept (Bong, Hong, 2010). Ideally, the correlation inside the same school subject, when the same trait (e.g. students’ achievements in computer sciences) is measured by different methods (e.g. by a standardized test and by a school grade) must be sufficiently large and larger than those between different traits (e.g. mathematics, native

Table 3  
An intercorrelation matrix reflecting the relationship between school annual grades and standardized test scores obtained during State Matura Exams; N = 2208

	Mathematics State Matura Exam Score	Lithuanian language and Literature State Matura Exam Score	Computer Science State Matura Exam Score	Mathematics Grade 12 Annual Score	Lithuanian Language and Literature Grade 12 Annual Score	Computer Science Grade 12 Annual Score
Mathematics State Matura Exam Score	1 (n=16832)					
Lithuanian language State Matura Exam Score	0,561 (n=16798)	1 (n=16804)				
Computer Science State Matura Exam Score	0,755 (n=2133)	0,532 (n=2132)	1 (n=2208)			
Mathematics Grade 12 Annual Score	0,709 (n=16825)	0,487 (n=16797)	0,637 (n=2133)	1 (n=16852)		
Lithuanian Language and Literature Grade 12 Annual Score	0,557 (n=16793)	0,684 (n=16773)	0,473 (n=2131)	0,617 (n=16820)	1 (n=16820)	
Computer Science Grade 12 Annual Score	0,513 (n=2133)	0,378 (n=2132)	0,478 (n=2208)	0,575 (n=2133)	0,479 (N=2131)	1 (n=2208)

language, computer science, etc.) assessed with either the same (e.g. a standardized test) or different methods (e.g. correlation between a standardized tests in mathematics and in computer sciences, and correlation between a school grades in mathematics and in computer sciences).

The test of the subject of computer science correlates quite highly with external criteria. The scores of the Computer Science Matura Exam (standardized test) correlate quite highly ( $r = 0.755$ ) with an analogous score of the mathematics test. Less highly it correlates with the estimate of the standardized test, which was obtained from the Lithuanian language and literature ( $r = 0.532$ ). The result obtained is theoretically foreseeable. Mathematics and computer science are much closer to each other, both in terms of content and in terms of cognitive operations required, than the philological discipline and computer science. The correlation between the score of the computer science test and the annual grade that the graduate derives from the subject of information technology is only  $r = 0.478$  points, and the coefficient of determination  $r^2 = 0.23$ , respectively. The coincidence for the estimates, which is only 23%, is very small. For comparison, in the subject of mathematics, the analogous correlation reaches  $r = 0.709$ , and in the subject of Lithuanian language and literature  $r = 0.684$ , respectively. These findings suggest that the system of school grade assessment for computer science may be inaccurate.

But that's not the case. It became clear that information technology is taught on two levels. With and without programming. In both cases, the graduate can receive a school assessment of up to 10 points, and in both cases the graduate acquires the right to

choose to take the Computer Science Matura Exam or not to choose to take it. The difference is that the Mathematics Matura Exam is divided into two parts a 'State Exam' and a 'School Exam', where the tasks of a 'state exam' are adapted to those who studied according to the full curriculum and the tasks of a 'School Exam', which correspond to the program of partial learning. Meanwhile, when taking the Computer Science Matura Exam, graduates of both programs take the same. This leads to the fact that the students who studied under a shorter information technology program are more diverse, since some of them independently learn programming, while others have not tried it. Both types of graduates who have a well learned a subject can get the maximum assessment that motivates them to take the exam. Meanwhile, during the exam, graduates who have not studied programming receive lower grades than those who studied it in the extended school program or independently. In the result, due to this variation, the correlation coefficient between the school assessment and the Computer Science Matura Exam is reduced. The fact that the State Exam in Mathematics was more often not taken by those graduates who studied according to the partial information technology program, led to a greater coincidence between learning achievements in Mathematics compared to Computer Science.

When deciding on the validity of the applied computer science test, good criterion validity is important. Estimates of the computer science standardized test, correlate relatively high with the subject estimates of other Matura examinations, which were also measured by standardized tests. This indicates that the computer science test examined in the study, at all, distinguishes well between capable and lagging students. And this is even though one of the two alternatives of the information technology program is only partially related to the Computer Science Matura Exam test.

Extremely noticeable effect of the graduate's gender was discovered by studying graduates' decision whether to take or not to take a freely chosen (optional) state exam in computer science. For comparison, in the general population of graduates in grade 12th who took the compulsory State Exam in Mathematics, the ratio of girls to boys is 57:43, respectively. It is known that in the lower grades of school, the ratio of boys to girls is close to the ratio of 50:50. However, more boys compared to girls "fall out" of the general education system after grade 10th, which creates an asymmetry of distribution in favor of girls in the upper grades. Because at the age of 16, when education is no longer compulsory, some students, especially boys, move to vocational training or the labor market. However, the study findings show that in that part of the graduate population that chooses to take the Computer Science Matura Exam, girls make up only 1/5 of all graduates.

#### *4.2. Gender Differences*

It was found that the gender of the student and competence in computer science are unrelated. This is confirmed by empirical curves of the accumulated frequencies which intersect at several points (see Fig. 2). Empirical curves show that profiles for boys and girls competencies distributions in their samples almost completely coincide.

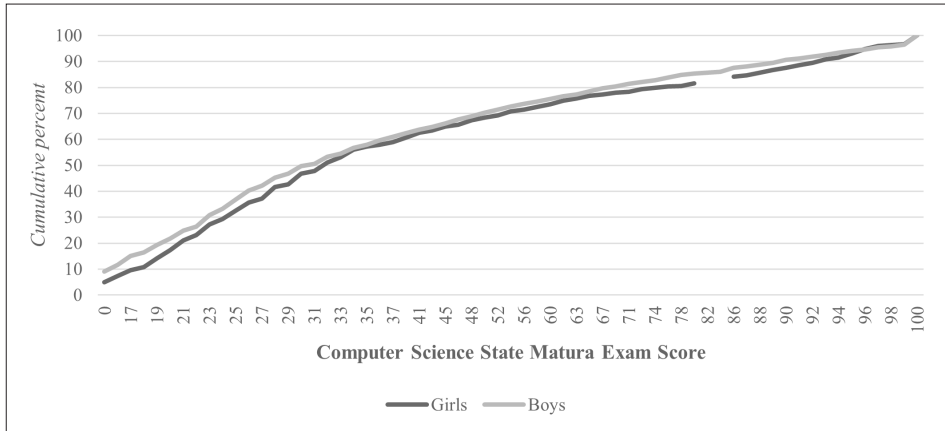


Fig. 2. Distributions of cumulative frequencies (%) of the computer science test by gender of the graduate; N = 2208.

The correlation between the grade scores distribution curves for boys and girls equals to  $r = 0.998$  and fulfils quite a wide range of grades from 0 to 100 (see Fig. 2). This means that both curves of scores distribution almost completely coincide. The results of Kolmogorov Smirnov Z test ( $p = 0.218$ ) also confirm the coincidence between both distributions. Comparison of grade distributions of boys and girls on the z-scale revealed that the difference found between the girls and boys groups averages on the standard z-scale is extremely small, reaching only 0.065 points. This is well below the critical threshold of 0.2 point up from which the interpreting of an effect size begins.

#### 4.3. Social Determinant

The exploratory analysis of non-dependent variables is reflected in Table 4, Table 5 and Fig. 3.

The social meaning of the variable presented in Table 4 in this study is that in Lithuania, an EU country with a population of less than 3 million inhabitants and experiencing a demographic crisis, the phenomenon of rural urban differences is very vividly

Table 4

The distribution of tested graduates according to whether they receive or do not receive a free meal and social assistance in school; N = 2207

Does not receive support in any form		Receives free school meals		Receives social support		Receives both free meals and social support	
N	%	N	%	N	%	N	%
2091	94,7	36	1,63	13	0,50	67	3,00



Table 5.

The distribution of the tested graduates according to the well-being type of the locality in which the school operates; N = 2204.

Geolocators of well-being type of the municipality the school operates	Graduates	
	N	%
Two major Cities of Lithuania (Vilnius and Kaunas)	693	31,4
The remaining three cities of the country (Klaipeda, Siauliai, Panevezys)	296	13,4
Six municipalities surrounding cities (Circuitous Vilnius, Kaunas, Klaipeda, Siauliai, Panevezys, and Alytus region municipalities)	368	16,7
Five larger regional centres (Alytus, Telsiai, Taurage, Marijampole, Utena)	158	7,2
Four Municipalities with resort status (Palanga, Druskininkai, Neringa, Birstonas)	27	1,2
The remaining regional municipalities with a population of at least 20 thousand and more	549	24,9
The rest of the regional municipalities, where the population does not reach 20 thousand.	113	5,1

manifested. It manifests itself in the classical sociological sense. The larger the urban-administrative unit the more conditionally greater social welfare it contains. This means a greater availability of social services, better access to educational and health institutions for the citizens, and greater the chances to obtain a better-paid job. The smaller it is and the more remote the municipality or urban unit, the less social welfare there is. Wage statistics alone show that wages in major cities are on average 30% higher than in remote regions. In the most general form, the types of municipalities in Table 5 are arranged by a ranking. The list of types is started by municipalities most leading by welfare and ends by municipalities that are most lagging behind in terms of welfare.

The majority of graduates who have taken the State Exam in Computer Science reach their school on foot, so the size of the sample is significantly reduced. However, the tested graduates distributed in acceptable proportions according to the way of travel to school and back from it (see Fig. 3).

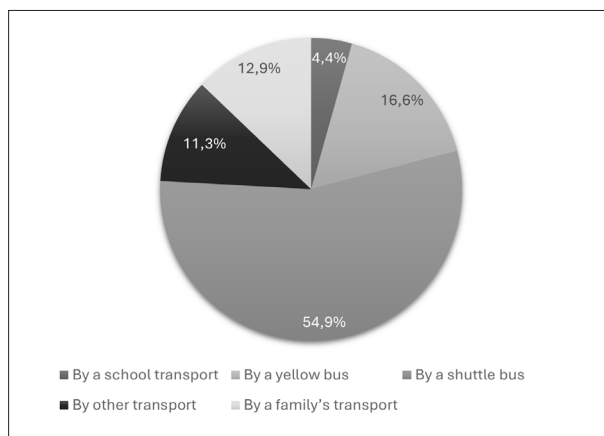


Fig. 3. Distribution of tested graduates according to the way of travel to school and back, N = 435.

Evaluating the results of the exploratory analysis of social variables, no surprises or unfavorable indications were found. All sample parts remain of optimal size and are suitable for quantitative analysis (see Table 4 and Table 5). The conditional exception is unless that statistical group of graduates who receive both free meals and social assistance. The number of such students when calculating the absolute size is 13, and it constitutes 0.5 percent. However, this did not adversely affect the study.

It was found that the allocation of free school meals and the receipt of social assistance have a fundamental impact on the assessment of the computer science test (see Fig. 4). The detected statistical regularity is as follows: the more socially vulnerable a graduate is, the relatively inferior are the results of his test from the computer science.

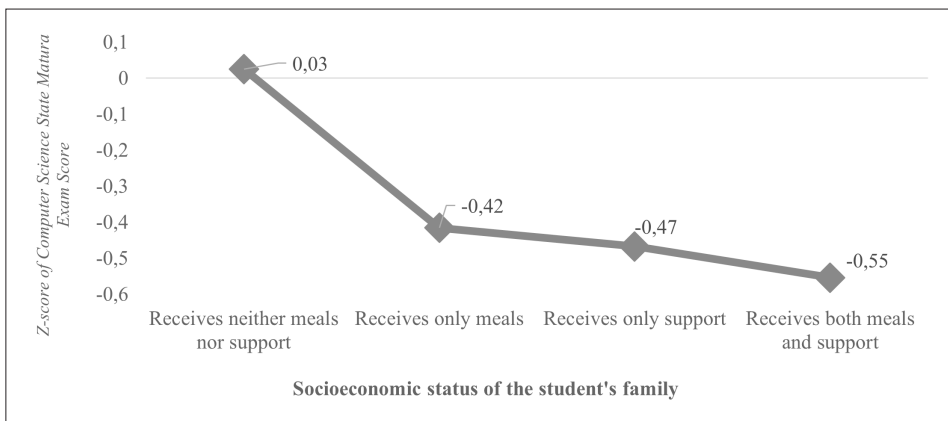


Fig. 4. Score of the computer science test on the standard z-scale, depending on the socioeconomic status of the graduate's family  $N = 2207$ .

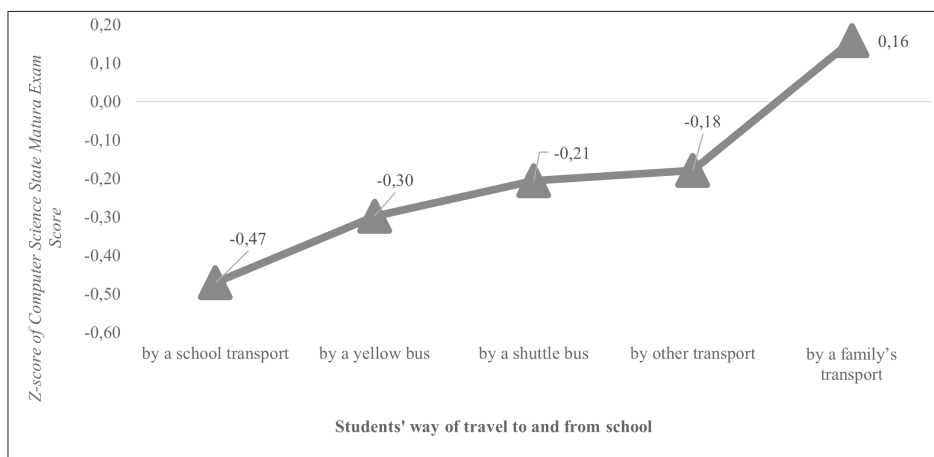


Fig. 5. Estimates of the computer science test on a standard z-scale, depending on the way the graduate's daily travel to school and back;  $N = 435$ .

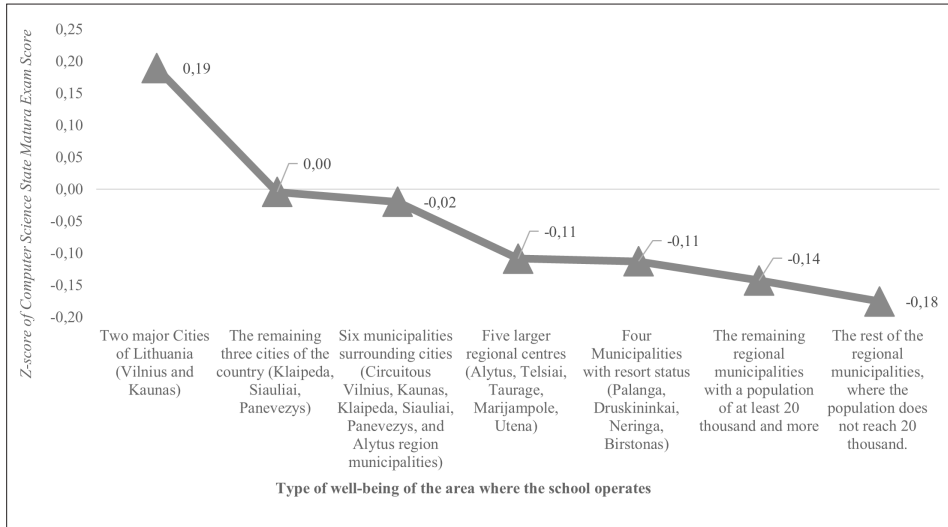


Fig. 6. Estimates of the computer science test on a standard z-scale, depending on the type of well-being of the area where the school operates;  $N = 2204$ .

The significance of the Kruskal Wallis test, at the  $N = 2207$ , is  $p < .001$ . The maximum found difference between the group averages on the standard z-scale, which can be treated as an effect size, is 0.58 points and significantly exceeds the critical threshold of 0.2 point.

It has been observed that the grades of the computer science test (state exam) and the way the graduate travels to school and back are statistically related (see Fig. 5). The largest difference between the group averages is 0.63 points on a zscale. The graduates who commute to school and back daily by private (family<sup>8</sup>) transport more likely achieve better results on the computer science test. The significance of the Kruskal Wallis test, at the  $N = 435$ , is  $p \leq .05$  ( $p = .02$ ).

The type of well-being of the area the school is located also influences the results of the computer science test (see Fig. 6).

The statistical regularity observed aligns with the well-established sociological concept of urban-rural differences (Ma *et al.*, 2020; Beynon *et al.*, 2016). For instance, the difference between two extreme groups, the two metropolises in the country and municipalities with a population of less than 20 thousand equals 0.37 points on the z-scale. The Kruskal-Wallis test, at the  $N = 2204$ , is  $p < 0.001$  ( $p = 0.000002057$ ). It confirms that the difference is significant.

<sup>8</sup> For the most part, it's about graduates who were taken by their parents to school and back by a family car. Only a small percentage of students who have already reached 18 and have driver's rights were able to drive a car to school on their own.

## 5. Discussion

### 5.1. Gender Effects: Paradoxes and Discrepancies

The number of graduates who chose to take the state computer science exam is not encouraging. When interpreting the findings of the present study, it is important to emphasize that this is not a single sampling study, but the total data from government statistics. However, only a relatively small number of Lithuanian graduates opt to take the Matura Exam in Computer Science, just 10.1% of the total population. In a digital high-tech society, such a trend is less than desirable. This is influenced by the fact that the aforementioned exam is optional. For those who pass the exam well, there is an opportunity to get state-funding for studying computer science. In a broader perspective, university graduates have the opportunity to attain leadership positions in a promising and well-paid labor market for programmers and software engineers.

Unfortunately, among the graduates who do choose to take the Computer Science Matura Exam, girls constitute only 1/5 of the cohort. This finding shows a clear disproportion with the evidence of gender discrimination. It's worth noting that women significantly outnumber men in the overall student population in Lithuania. According to 2022 data, women constitute 55% of all students in universities in undergraduate studies and 61% in master's studies. In this context, the data from the Informatics Europe Higher Education Data Portal for 2019–2020 are particularly telling. For example, in 18 European countries, the share of girls studying in the first year of studies in computer science is only 18.4%.<sup>9</sup> The picture of youth preferences in computer science is as if from a textbook on the history of classical feminism and gender studies. For boys prestigious, well-paid professions, as well as the positions of programmer or software engineer, and for girls the job in the office, nursing, social work, education, middle-level positions in the civil service, trade, etc. Anyway, discriminatory gender asymmetry in the field of computer science and studies is also found in those countries whose economies and democratic traditions are stronger than in Lithuania.

Oppositely, the discovery that the results of the computer science test are not affected by the gender of the graduate shows that there are fundamental progresses in Lithuanian education in the implementation of the gender equality policy. For example, a few decades ago a similar study was carried out and assessed the competences in computer science of young people studying management and economics at the university level. Findings revealed extremely contrasting differences to the detriment of women (aparnienė, Merkys, 2005). The analysis of the latest total census data revealed discrimination in this regard no longer exists. The growth of information literacy in the mass and especially in the youth population was possibly positively influenced by the fact that households that purchased new computer equipment and software were compensated a part of the personal income tax in Lithuania. Moreover, in recent decades, the comput-

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<sup>9</sup> <https://www.informaticseurope.org/data-portal/?page=index.html>

erization of schools in the country has been given special attention and investment by decision-makers.

The fact that social factors as the socio-economic status of the family, the way the child travels to school and back, or the type of well-being of the area systematically affect the competences of graduates in the field of computer science should not be surprising. Many large-scale studies, including TIMSS, PISA, PIRLS, ICILS show that social factors are the strongest variables of learning achievements (Avvisati, 2020; Broer *et al.*, 2019; Gustafsson *et al.*, 2018). This universal statistical regularity is valid for all subjects taught: mathematics, science, literature, etc. including computer science too. It has even been observed that students from weaker social backgrounds perform relatively worse when taking online tests than when dealing with the traditional paper-pencil test (Reiss *et al.*, 2019). Discrimination in education from a social perspective in Lithuania is mainly manifested in two dimensions. These are the social stratum of the student's family and the urban-village differences.

### *5.2. The Effects of Social Conditioning Still Remain Clear*

The fact that social factors as the socio-economic status of the family, the way the child travels to school and back, or the type of well-being of the area systematically affect the competences of graduates in the field of computer science should not be surprising. Many large-scale studies, including TIMSS, PISA, PIRLS, ICILS show that social factors are the strongest variables of learning achievements (Avvisati, 2020; Broer *et al.*, 2019; Gustafsson *et al.*, 2018). This universal statistical regularity is valid for all subjects taught: mathematics, science, literature, etc. including computer science too. It has even been observed that students from weaker social backgrounds perform relatively worse when taking online tests than when dealing with the traditional paper-pencil test (Reiss *et al.*, 2019). Discrimination in education from a social perspective in Lithuania is mainly manifested in two dimensions. These are the social stratum of the student's family and the urban-village differences.

The study explains the relationship between computer science test grades and graduates' travel to and from school. The real reason is not the physical way of traveling itself, but its social subtext. Transportation of child daily to school and back by a family transport in fact describes a family that, according to its socio-economic status, should at the very least be defined as a strong middle-class. Therefore, the confident predictors of relatively better achievements in computer science are a favorable socio-economic status of the family, cultural capital, the capacity of the family to regularly update computer equipment in the household, as well as the ability of the family to regularly transport children for educational purposes, etc. Namely the relatively higher grades of the computer science test arise from this.

In Lithuania, the distribution of population density leads to the fact that on the periphery poorly urbanized locations remain relatively neglected in terms of well-being in comparison to thriving areas of metropolitans in the country as well as the circular municipalities surrounding them. This is an objective challenge for the state's social and

educational policy. Higher level decision-makers should operate more decisively with two aligned tools of governance. First, it is the optimization of the network of schools on the periphery. Because in small schools it is difficult to have constantly updated computer classes, to lure a good specialist who has received a modern education into the position of a teacher or computer science engineer for a full-time position. Secondly, if it has been decided that school on the periphery remains, it would be appropriate to apply the principle of positive discrimination, with relatively higher funding for them, as is the case in Finland.

### 5.3. *About Assessment and Didactics*

The data from the study allowed for making observations and formulating specific insights about the didactic framework of computer science in school, although this was not even intended at the beginning of the study. The empirical curve of the scores of the test of the computer science (Fig. 1), which consists of total census data, is eloquent from this point of view. Here it makes sense to distinguish two aspects: 1) epistemological (metrological) and 2) ontological:

- 1) The configuration of the empirical curve (an epistemological perception): The empirical curve's configuration suggests that the internal structure of the computer science test task set could be improved in the future. It makes sense to integrate more tasks with moderate difficulty level into the test, as well as slightly more difficult than moderate tasks. This would eliminate the frequency pit that occurs in the middle of the scale and in the second half of the scale. This recommendation makes sense only if the level of knowledge and competencies of graduates of different generations is relatively stable. This condition is not automatically guaranteed. Let's say that the difficulty of the test tasks has historically been adequate, but a weaker cohort of students, exhausted by the challenges of COVID-19, came to take the exam. As a result, the curve may deviate somewhat and be suboptimal. However, there are indications that the test task creators have a good understanding and a feeling of what results in computer science test is and should be in the graduate population. There are 3.5% of students who achieve the highest theoretically possible test score, which is 100 points. It's also favorable that there is an optimal percentage (8.5%) of graduates who fail the test. However, it's not talking about a lower-level school, but about the state high school graduation exam, which should ideally be valuable. The exam is not obligatory, but optional, so it does not have a decisive influence on the further educational biography of the graduate. However, it's good for a young person objectively to check competence in computer science. An objective test can help a young person grasp his dreams and illusions, encourage him more rationally and more precisely to choose his studies and career direction.
- 2) The content of the empirical curve (the ontological perception): The obtained empirical curve can also be interpreted from an ontological perspective, that

is – to hypothetically decide on some dysfunctions of the didactic system of school informatics. From the educational goals and public interest perspective, educational results should ideally form an asymmetrical partially bell-shaped curve, significantly shifted to the right, to the area of high estimates. This configuration of the curve implies that most of the graduates have mastered most of the learning material. The conventional symmetric normal distribution is more suitable for measuring innate mental characteristics such as IQ. It means that the most of the subjects – 68.4% – reaches only an average level of development of the corresponding characteristic<sup>10</sup>. Such a distribution and such a state partly negate the existential meaning of education as a purposeful and effective activity. The empirical curve of the computer science test found in this study, resembling a “U” shaped curve, either a flat right-leaning bowl, marks an anomaly from an educational perspective. This configuration of the empirical curve indicates that the teaching and learning of informatics in the Lithuanian general education school is not very effective.

The majority of graduates learn informatics rather poorly. In the middle of the scale, a frequency pit is generally found at the average level of competence in computer science. One can only guess how unfavorable the situation would be if the Computer Science Matura Exam in Lithuania was not optional, but mandatory? The failure rate would likely be much higher than the 8.5% found now. It is likely that those graduates who are motivated, feel sympathy for computer technologies and are interested in this field took the freely optional exam en masse.

The fact that the correlation between the annual grade in information technology, as assigned by teachers, and the estimates from standardized test in the same subject is relatively small should be viewed unfavorably. In this case, it is appropriate to consider the test scores as an external criterion, according to which the validity of the school grading system is assessed. Especially since the correlation between the State Mathematics Matura Exam and the State Computer Science Matura Exam is quite high ( $r = 0.75$ ). It is obvious that the system of grading for the information technology subject in the Lithuanian general education school is insufficiently functional. If essential components of the educational process, such as learning outcomes and their assessment system, exhibit weaknesses, then a hypothetical assumption can be made that this circumstance negatively affects the entire didactic process, on the other hand, the didactic process itself represents insufficiently effective.

That the intercorrelation matrix of computer science tests, annual grades and other school subject test scores does not satisfy the conditions formulated by the Multitrait-multimethod concept (Bong, Hong, 2010) is an eloquent fact. It shows that both the system of evaluation by school grades and the system of centralized high school exams based on standardized tests have untapped opportunities for improvement in Lithuania. First of all, it is necessary to more smoothly harmonize the contents of both the information technology subject program and the tasks of the Matura Exam. In order to explain

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<sup>10</sup> In the case of a normal distribution, the mean including standard deviation, falls within the range of 68,4% of total observations.

some anomalies in informatics education empirically found by using statistical methods during this study, a separate independent study should be conducted in the future. This article is limited to determining the impact of social factors on the level of computer science competencies.

## 6. Conclusions

The study allowed us to draw specific conclusions:

1. In computer science male graduates remain predominant in the General Education School of Lithuania. The relative distribution of graduates who take the State Matura Exam in Computer Science is strikingly asymmetric: 20% girls and 80% of absolvents boys. The discrimination by the gender is clearly manifested, since the aforementioned exam provides an opportunity to choose free computer science studies at the university.
2. In that population graduate girls, who nevertheless chose to take the computer science maturity exam, was no differences in testing (and, accordingly, competence in computer science) compared to the analogous population of graduate boys are detected. Graduates' girls and boys demonstrate the same test results in the field of computer science and, accordingly, the same level of competence in computer science. No difference by gender in the results of education observed.
3. The results in computer science test of graduates are systematically influenced by social variables. Graduates representing a socially weaker social stratum, i.e. receiving free meals and social support at school, demonstrate relatively worse results of the computer science test and, accordingly, a lower level of digital literacy. Graduates who travel to school by private (family) transport demonstrate relatively higher results of the computer science test than graduates who reach the school in other ways. The type of well-being of the area where the school operates also systematically affects the results of the computer science test. In metropolitan areas, where in the conditions of Lithuania there is more diverse well-being, school graduates demonstrate relatively higher test results and a higher level of competence than graduates from small municipalities on the periphery, where the population experiences more poverty.
4. The system of assessment of the computer science subject by annual school grades and standardized tests is currently not optimal in Lithuania and could be improved. The correlation between annual grades and a standardized test is too low and testifies to some dysfunctions in the assessment of achievements in school grades. The set of tasks of the standardized computer science test used for the purposes of the Matura exam is not optimal in terms of their severity.

It can be stated that the teaching of the subject of information technology in Lithuania is characterized by conditional dysfunctions and can be improved. This is evidenced by too weak correlation between the annual grades of information technology and the standardized test of Computer Science Matura Exam, which is significantly lower than in other school subjects (mathematics, literature). It is also a fact that the ratio of gradu-



ates who reach the average and/or higher literacy rates in the graduates' population taking the exam is too low. Meanwhile, the relative size of graduates with a low result in computer science test is relatively excessive.

## **7. Recommendations**

The results lead to concrete proposals, such as adapting the curriculum to the examination content, introducing more intermediate-level tasks into the examinations and providing additional support for students from socio-economically disadvantaged backgrounds. It would also be rational to address the issue of gender differences through targeted initiatives and improved teacher training. It would be wise to integrate practical skills into teaching, improve educational infrastructure in rural areas, and improve the school grading system to better reflect students' competencies. These reforms are aimed at creating a socially just and effective system of education in the field of informatics.

## **8. Limitations**

In this study, statistical regularities were detected when working with a total census data. This is a type of a survey, in which the entire target population is studied. During this study all graduates who in 2023 in Lithuania took the Computer Science Matura Exam were studied by analyzing standardized testing data ( $N = 2208$ ). However, the study of data from only one instantaneous measurement does not eliminate the risk of fallacy and incompleteness of the conclusions drawn, which is caused by factors such as the uniqueness of the cohort or the circumstances that have arisen at that time. Hypothetically, it is possible that the detected empirical distribution of the anomalous form in the test results is a simply unique misleading fact of the individual measurement obtained from the data of a single sample. Let's say it's covid-19 and distance learning's unfavorable consequence for the school, when students' achievements have objectively plummeted somewhat downwards. The anomalous distribution obtained from the 2023 data was possibly uncharacteristic of previous measurements of Total census. This interpretive hypothesis would have to be verified in the future in order to draw the boundaries of long-term statistical variation. However, from the point of view of the truth of the fact, when the interpretation is valid for the study's scope, the data reveals the statistical regularities valid for the studied population and adequately defines the distribution characteristic of it.

## **9. Future Work**

The sequence and logic of the future research comply with the mentioned limitation. For the purposes of further analysis, analogous total census data of the Computer Science Matura Exam can be studied in the coming years 2024–2030.

Accordingly, as many as 8 instantaneous measurements of annual total census data would be available. All calculations and analytical procedures would be repeated to confirm or refute the hypothetical regularity found.

No less useful here would be the empirical cross-cultural studies, which convey the analogous data from other education systems for further analyses. This could answer an important question. In other words, what do the findings of Lithuanian study mean? Is this just about the local specificity of a separate national education system or have more universal, cross-cultural statistical patterns about the process of education in the field of computer science been discovered?

## 10. Statements of Open Data and Ethics

For the purpose of survey, the data on education statistics collected in the National Education Management Information System were used. The name of the graduate, the specific class in which the graduate studied remained unknown to the researchers. In the matrix of anonymized data which was transmitted to researchers in March 2024 at their request, it was possible to identify the gender of the graduate the scores of the tests performed, the municipality where graduate studied, the method of transportation to the school and whether the graduate received free meals and social assistance at school. Working with anonymized large data of state statistics eliminates the risk of harming the interests of both an individual and social group.

## 11. Acknowledgments

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