Critical thinking development in students during coding in the subject of "information and communication technology"

Case study at "Harif Halil Sulaj" high school, Mamurras

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Abstract

Background: Coding is solving problems while working. In coding, you must visualize and create map minds of your task or issue and break down the problem into smaller and more manageable parts, so that you can solve them more effectively and efficiently. So overall, coding includes the same process as critical thinking, and that of critical thinking process can be used very well and effectively in coding. Purpose: Exploring the possibilities and perspectives of the interaction between coding and encouraging, also developing critical thinking among students in the 15-18 age group. Evidence of students' help in diversifying the ways of gaining knowledge and practical skills, as well as enabling young people to be more involved, among the approaches to education in the contemporary educational process. Method: This study is conducted at the "Arif Halil Sulaj" high school, Mamurras. To achieve the study objectives, a field survey was conducted through questionnaires and focus groups, both for teachers and for students of the "Arif Halil Sulaj" high school, Mamurras. Conclusion: Based on the searched results, it was evidenced that coding has a significant impact on increasing the involvement of students in the most active lessons and encouraging critical thinking, enabling them to solve problem situations independently, especially in the subjects of exact sciences. The recommendations determine the need to extend the curriculum in general with coding hours and algorithms as well as the addition of ICT hours in the 11th grade.

Keywords: *Critical thinking, coding, programming language, ICT, curriculum*

Introduction

The learning process is a long process that lasts throughout life and school has a decisive role in training the individual and making him capable of solving problems practically. To reach such a level, during the years of schooling, the teacher has the duty to encourage the student's ability to think critically.

Critical thinking includes the ability to analyze, argue and draw conclusions using inductive or deductive reasoning, judging, and evaluating various problems leading to their solution. The knowledge that the student has from earlier learning is important, but not a sufficient condition to develop critical thinking within a given subject. The main reason we chose to carry out such a study is that studies of this nature are missing in the field of national studies and this work can be

considered as a pioneer of its kind. Critical thinking is of vital importance since we live in an age of information technology where individuals are confronted with a large amount of information every day and therefore need to know how to distinguish between truths and falsehoods. (Lorenzo & Dziuban,2006).

Aim/ Research question

2.1 How much does programming affect the promotion and development of critical thinking in high school students?

The main object of this study is to identify in a general plan the main aspects of the coding impact coding on the activation and promotion of critical thinking. How much do the use of coding exercises motivate the student, how does this way of education affect interdisciplinary connections and in accordance with the philosophy of lifelong learning. Another aspect of the study is the efforts to measure how many effects each line of algorithms and programming has in promoting critical thinking, as well as inclusiveness and improvement in the ICT subject, with the aim of the efficient development of the entire teaching-educational process.

2.2 The hypothesis of the study

The determination of the hypothesis, the research question and the variables constitute the basis of the study. The treatment of the literature, the experience of our team and the individuals who contributed to this study, as well as the implementation of the combined approach, has enabled the treatment of the problem of viewing the ICT school curriculum in grades 11, as well as the part of the coding in a detailed form.

The hypothesis of the study is:

H0: The implementation of programming in the classroom has no impact on the development of critical thinking in students.

Ha: The implementation of programming in the classroom promotes the development of critical thinking in students

Methodology

Questionnaire and interview questions design was done with the aim of coming out as a result of the compatibility between the coding and the students' interest in this field, being in coherence with the chosen topic and other elements such as: the hypothesis, the research question "How Does programming affect the promotion and development of critical thinking in high school students?", to conclusions and recommendations.

The questionnaires were compiled, relying on the review of the relevant literature, adhering to the nominal Likert scale, which expresses the assessment of

five points, from 1-5, where consisting: 1- I do not agree at all; 2- I do not agree; 3- Undecided; 4- I agree; 5- Completely agree.

Based on the scaled assessment given by the respondents, it is possible to measure the level of agreement or disagreement with the question in question, which focuses on the interest students have in coding and how it encourages critical thinking. The Likert scale is constructed according to an order where higher numbers indicate the degree of pronouncement related to the question. The questionnaires were completed by students and teachers at the "Harif Halil Sulaj" school. Meanwhile, during the contact with the interviewees, care was taken to be clear and give their opinions as if they really believed them. How to maintain anonymity in accordance with all ethical rules.

Regarding the characteristics of subjects, students, teachers as described in the first part of the questionnaire, we focused on their algorithms and coding skills, classes and gender. The questions of the questionnaires as well as those of the interviews are formulated based on our experience and knowledge, because in the field of our work there are no standardized questionnaires nor similar studies that we could base ourselves on. The respondents had spaces to express themselves regarding each question, by means of the Likert scale. To determine the level of reliability, the questionnaire was initially piloted with 5 students and 1 ICT teacher at the secondary school of the city of Mamurras. The head of the school was interviewed for the in-depth interview.

Population and sample

The population consists of students, ICT teachers and school leaders. The maximum number of the population is 349 students in total, of which 163 are males and 186 are females. The study population is a number of 349 students from which a sampling of 60 students from grades 10, 11 and 12 were randomly selected. Of which 41 are females and 19 are males. Questionnaires were sent to all students of 10,11,12 grades, while 12 students and 2 ICT teachers were selected for the focus group interviews.

The champion was taken from "Harif Halil Sulaj" high school, Mamurras. The analysis of the secondary data in this study consisted of the review of the existing literature. The selection of interviewees was conducted purposefully.

The teacher's interview contains 4 sessions: 1. Evaluation of the ICT Program which contains 4 questions; 2. Strengths of the ICT Program which also contains 4 questions; 3. Weak points of the ICT Program which contains 3 questions and 4. Opportunities for Improvement of the ICT Program which contains 5 questions. The interview with the focus group students contains 3 sessions: 1. The ICT program strengths which contains 3 questions; 2. The ICT program weaknesses

which contains 3 questions and 3. Opportunities for improvement of the ICT program which also contains 3 questions.

The in-depth interview contains 6 questions focusing on the school curriculum and its scope, number increase of ICT lessons in 11th grade. As for the questionnaires, they were electronically distributed to all the classes of the school where the study was carried out. This questionnaire was conducted through Google Forms and it is divided into 3 sessions; Session one contains 10 questions focusing on the use and mastery of technological devices by students; Session 2 contains 6 questions focusing on knowledge and communication skills through technology; Session 3 contains 9 questions focusing on coding skills.

Sample description

2 ICT teachers, one female and one male, with a university degree and of over 10 years of work experience were selected in the sampling process. 12 students were intentionally selected based on 10, 11, 12 classes and also the school principal took part in the sampling process.

General data for the teachers who took part in the study:

In the semi-structured individual interview, there participated; 1 female and 1 male.

- The teachers who were interviewed were from the municipality of Kurbin, Mamurras high school.
- The age of the interviewees varied between 35-55 years.
- The level of the interviewees is high post-graduate.
- Their experience as a teacher over 10 years of work in education in the fields of ICT and Physics
- Regarding civil status: married - both interviewees married.
- General data for the students who took part in the study.
- The age of the respondents varied between 15 - 18 years.
- The total participants in this study were (n=113)
- From the total number of teacher participants, (n-1) is female, and (n-2) is male, while the average age of interview participants is (over 35 years old).
- None of the participants in the questionnaires has completed higher secondary education (n=110).

TABLE 1. Structure of teacher participants

	Total 3	N	%
Gender			
	Male	1	33,33
	Female	2	66.66
Education level			
	University	3	100
	Bachelor degree	3	100
	Master degree	3	100
	Years of teaching experience	Mbi 10	100
Age			
	Male	Mbi 48	33.33
	Female	Mbi 35	66.66
	Civil Status	Te martuar	100

TABLE 2. Structure of student participants

	Total 3	N	%
		110	100
Gender			
	Male	45	40,90
	Female	65	59.09
Education level			
	High school	110	100
Age			
	Male	15 -18 vjec	40,90
	Female	15 – 18 vjec	59,09

The student selection in the school was based on the random number principle. Based on the school principal attitudes we selected a deliberate sample for this study.

		Frequency	Percentage (%)
Valid	Completely Disagree	2	1.7
	Disagree	4	3.3
	Neutral	20	16.7
	Agree	42	35.0
	Completely Agree	42	35.0
	Total	110	91.7

Results/ Focus - Group Interviews & In-Depth Interviews Analysis

Quantitative data analysis

Differences and comparison of student attitudes depending on the dependent variables.

Research question: How much does programming affect the promotion and development of critical thinking in high school students?

The hypothesis of the study is:

H0: The implementation of programming in the classroom has no impact on the development of critical thinking in students.

Ha: The implementation of programming in the classroom promotes the development of critical thinking in students

Below we present the standard deviation table and the average that connects the independent variable with exact sciences subject.

Regarding the question of whether coding helps students better absorb other subjects, especially science subjects, the average response is 4, which means that the students think that coding helps them in science subjects such as Mathematics and Physics.

TAB.2 Coding helps in science subjects (such as physics, math, etc.)

	N	Mean	Standard deviation
Coding helps in science subjects (such as physics, mathematics, etc.)	110	4.0727	1.93563
Valid N (list)	110		100.0

N	Valid	110
Mean		4.0727
Median		4.0000
Standard Deviation		1.93563

CHART 1. Coding helps in science subjects

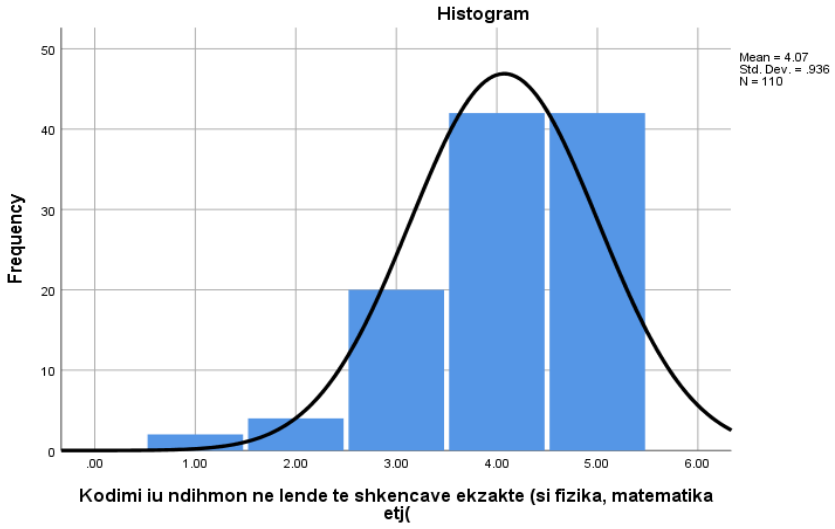
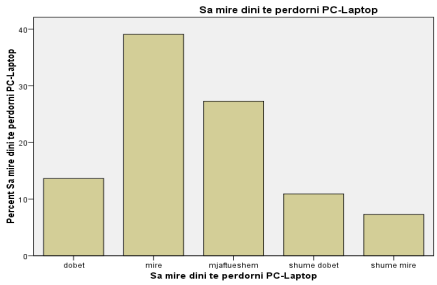


TABLE 2. How well you know to use a laptop or PC

		Frequencies	Percentage (%)
Valid		2	1.8
	bad	15	13.6
	well	43	39.1
	enough	30	27.3
	very bad	12	10.9
	very well	8	7.3
	Total	110	100.0

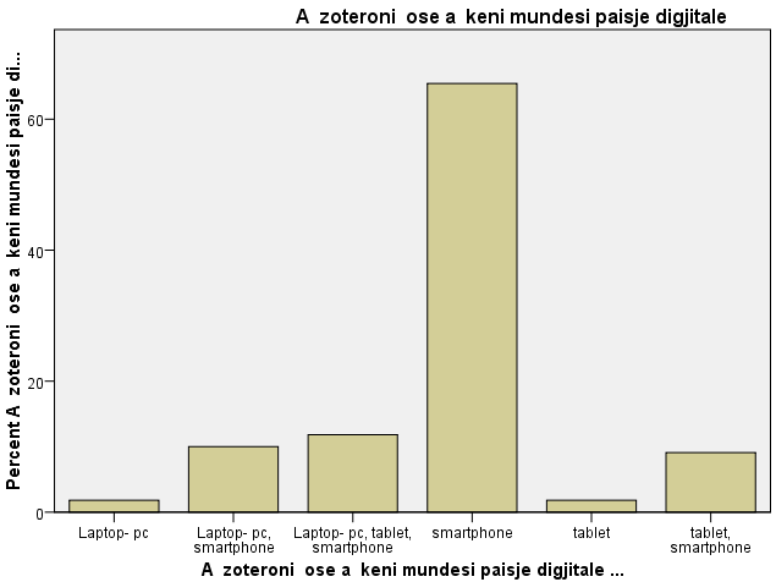


Regarding the students' abilities to use a laptop or PC, the analysis of frequencies and percentages presented in table 2 shows that we have a percentage of 7.3% very good and 1.8% poor, on the 5- very good and 1- weak t. In the evaluation scales 3- enough (27, 3 %) not at all and 2- well, we have a higher percentage of students who do not know how to use a PC or laptop. The results of this analysis highlight a problem that shows the lack of computers at home for the students and the lack of enough hours of laboratory practice at school.

Do you own or have access to digital devices such as (choose more than 1 alternative)

TABLE 3. Do you own or have access to digital equipment

		Frequency	Percentage (%)
alid	Laptop- pc	2	1.8
	Laptop- pc, smartphone	11	10.0
	Laptop- pc, tablet, smartphone	13	11.8
	smartphone	72	65.5
	tablet	2	1.8
	tablet, smartphone	10	9.1
	Total	110	100.0



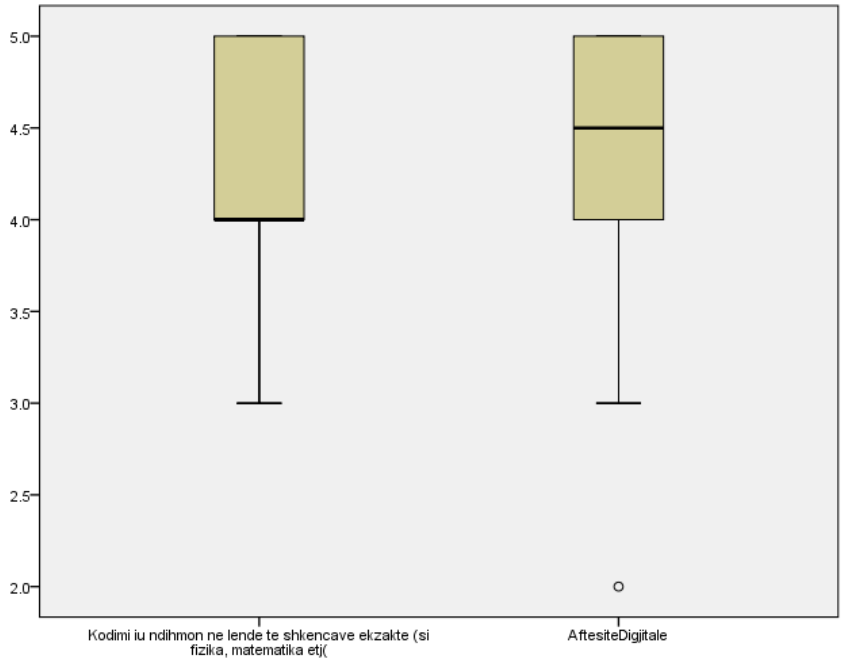
Another point of the quantitative analysis was the question of whether the students of the Harif Halil Sulaj school own digital devices such as laptops, PCs, smartphones, etc. From the results presented in the Table and in the graph above, it is estimated that only 1.8% were able to have a PC, Laptop or tablet, this result is also presented in 5.5 Table, while 65.5% of the respondents claimed that they protect a smartphone. Only 11.8% claim that they own three technological devices such as PC, tablet and smartphone. These indicators are not very positive in terms of improving their digital skills, since in some ways the lack of equipment limits their practice beyond the classroom. Based on these data, the laboratory practice hours at school in the ICT subject should be added to students of higher secondary education.

Correlation Analysis

TABLE 9. Coding helps in science subjects (such as physics, mathematics, etc.)

			Coding helps in science subjects (such as physics, mathematics, etc.)	Digital Skills
Spearman's rho	Coding helps in science subjects (such as physics, mathematics, etc.)	Correlation Coefficient	1.000	.654**
		Sig. (2-tailed)	.	.000
		N	110	110
	Digital Skills	Correlation Coefficient	.654**	1.000
		Sig. (2-tailed)	.000	.
		N	110	110
**. Correlation is significant at the 0.01 level (2-tailed).				

Spearman's Rho was used as a technique for evaluating the correlation between the variables "Digital Skills" and "Coding, it is helpful in subjects of exact sciences (such as physics, mathematics, etc.) since the variables were measured on an ordinal scale (Likert 1=very weak, 2= weak, 3=neutral, 4=good, 5=very good). The correlation analysis with the Spearman's Rho method evidenced a moderate to strong relationship between the "Digital Skills" variable and "Coding variable which is helpful in the exact science subjects (such as physics, mathematics, etc."). The results according to the table "" indicate a positive and statistically significant Spearman's Rho correlation coefficient between the 2 variables ($r = .654$, $n = 110$, $p < .0005$). The distribution of values for the "Digital Skills" and "Coding variables helps in the exact science subjects (such as physics, mathematics, etc.)". It is presented through the boxplot below:



The reliability analysis of the questionnaire was carried out by calculating the reliability coefficient of the Cronbach's alpha questionnaire. The Cronbach's alpha coefficient was =0.083, passing the acceptable reliability threshold.

Furthermore, the results of the reliability analysis showed that the removal of any of the questions did not increase the reliability (thus increasing Cronbach's alpha). For this reason, the questionnaire was not changed further. Statistical analysis was performed using statistical processing software "IBM SPSS Statistics 26". The statistical techniques used include: Descriptive Analysis through statistical indicators, frequency analysis, visualization through graphs.

Qualitative data analysis

The participating teachers in the study have an experience of over 10 years in the teaching field, specifically in the ICT subject, as well as in computer networks and web developers, certified as CISCO instructors. During the preliminary pilot, based on the experience of the teachers, it was considered to build the interviews, with a focus on extending the curriculum with hours of coding. The impact of coding on fostering critical thinking in students, as well as how interdisciplinary coordination is developed and how problem situations can be solved through coding in both exact and social science subjects.

Their answers to most of the questions were in unison as the problems faced with the extension of coding hours are the same. Based on the questionnaire analysis, not only from the questions presented in the tables, but the detailed analysis of the complete questionnaires and the answers of the interviewed teachers, we conclude there are two main problems:

First: Coding lessons directly affect the stimulation of critical thinking among students, making them more involved. For this reason, their number should be increased and extended along the lines, starting with the line of algorithmics, which is a line that focuses on mathematical logic, making in this way an interdisciplinary interaction between the solutions to the exercises and math problems expressed in digital form. Also, HTML, CSS, Java Script influence the stimulation of creativity among students, making them skilled in group work. An important conclusion for this case study is the addition of laboratory practices, since ICT is a subject that is a practice in itself.

Second: two of the interviewed subjects presented a problem encountered in the curriculum of 11th grade. The hours of ICT 11 must be doubled because they judged it insufficient by looking at the topics of the program. While one of the subjects for the above-mentioned matter does not agree with the other two subjects, he considers that the number of hours in the 11th grade is sufficient.

Another problem that was addressed in the form of a free conversation with the teachers was the lack of possession of digital devices in their homes, so that they could practice the new knowledge acquired at school. During the conversation, it was discussed that these types of absences, especially in the possession of a PC or laptop, among young people in general, as well as in rural areas, is a very big problem, which directly affects the reduction of learning performance in schools. That's why it became more and more difficult for the few in the Harif Halil Sulaj school, which has a functional ICT cabinet for 16 years, to put as much efficiency as possible into the classroom. But this kind of suggestion takes a larger dimension, and it would be very useful for all the students on the school site in Albania, if we would have the scope of the curriculum.

Discussion

Technology means all types of technology, which are used to exploit and manipulate information, so we have a combination of Technology with Information and Communication. The use of technology in our schools has changed significantly in recent years. Thus, to equip students with the necessary technological skills, we must use new learning methods compared to the methods used in traditional learning (Warschauer and Matuchniak 2010; Reci, 2018).

Technology and technological tools have become part of education in schools and the aim is to use technology in classrooms as a tool that develops and furthers the learning process. The efficient use of recent technologies that supports the students' thinking process, increases the student's ability to concentrate on learning, improves understanding and transfers the content to a long-term memory (Reci, 2018). The effects of the use of technology in educational institutions have been researched many years ago by researchers in the field of education, through which it has been proven and promoted that technology can assist in various educational processes (Brown, 2012, Dermentzi et al., 2016, Hung & Yyen, 2010), have a positive impact on supporting student learning (Dyson et al., 2015), assist teachers, and help them in professional advancement and development (Manca & Raineri, 2017) (Donelan, 2016). Therefore, the integration of technology in the classroom has been promoted and supported for many years now in different countries of the world (Cope & Ward, 2002).

With the information development and communication technology and their use in learning processes, in addition to offering greater opportunities to realize flexible learning, at the same time learning becomes more open, through which the aim is for students to be more independent and self-determined, responsible for learning (Goode et al., 2007) and acquire self-regulatory skills in relation to goal setting, self-monitoring and adaptation. While, the same opportunity allows teachers to promote active learning so that learning is engaging and effective (Collis, 1998), making teachers more facilitators of the learning process (Wiki, 2019; Huang, Liu, Tlili, Yang, W ang, et al. 2020), removing them from the responsibilities to carry out the teaching as one, and also giving students responsibility (Goode, 2007). Moreover, the learner-centered approach, with the development of technology, is considered a key component of flexible learning, as it empowers students and teachers to share information with each other in a two-way manner (Lundin, 1999).

As we have presented in the above paragraphs, critical thinking includes the ability to analyze, argue and draw conclusions. An inevitably factor related to the latter is programming. (Wing, Jeannette M., 2006) suggested that students should learn Critical Thinking (through code learning) so that they can solve problems in the same way a computer does. Computer programming has always been one of the essential and compulsory modules in computer science education. It has deep connections to computing, mathematics, science, design and technology, and provides insights into both natural and artificial systems. With advanced coding tools built specifically for kids, e.g. With Scratch from MIT, teachers can now easily help students develop the core competency known as the "4Cs," which stand for "Critical Thinking and Problem Solving, Communication, Collaboration, Creativity, and Innovation," which can help developing the critical thinking skills needed to meet the challenges of the 21st century.

In an analogous way, we have used this tool in previous years and the effectiveness in critical thinking and problem solving for 11th graders which has been at quite satisfactory levels but considering that this tool is suitable for older ages. Small, it is intended that these age groups focus on learning programming languages and Data Base. As well as website security systems such as Cryptography. During the development of this research work, it was evident that the introduction of coding in school leaves in the higher secondary education has a very positive impact on the students on the site, even on the students on the site with a level below the average since this method of taking care of me is quite attractive and challenging. Programming what it is like to play and with this form makes them focus and take the tasks as challenges to be won.

Likewise, the algorithmic part which is developed in the 10th and 12th grade is a challenging line to learn on the site since this line is more directly related to mathematics and real-life situations. Also, from the data processing in SPS and focus group interviews with ICT teachers, it was found that coding has a direct impact on the promotion and development of critical thinking among students aged 15-18 years. Similar results regarding the effect of coding on problem solving and reasoning were shown by other authors such as (Choi B et al., 2013, Kordaki M et al., 2012, Numanoglu M et al., 2017)

While learning to code, students managed to present elevated levels of problem-solving skills, unlike before learning to code. On the other hand, in their study Karaduman & Emrahoglu, 2019, showed that in addition to the development of problem-solving skills, computer-based learning experiences also positively influenced the sustainability of students' learning outcomes. Similarly, to our results regarding metacognitive skills, Ong GKV et al., 2017 also concluded that education through coding promotes creativity, critical thinking, and problem-solving skills. All of this may suggest that Coding Education has a positive effect on learning performance and some 21st century skills.

During the development of the case study, one of the most surprising indicators for us was the significant social skills improvement of our students through computer science. Such results are also supported by Ozdem C& Tezer M, 2018 who showed that students who learned coding practiced their metacognitive thinking, but also social skills at elevated levels. Based on the students' views, coding teaching has a positive effect on their perceptions of subject self-efficacy.

Conclusions

The high school curriculum in the ICT subject has undergone changes over the years, highlighting some concrete issues that have become the object of study. The problem of the lack of programming and algorithmic hours is also an open

issue that will require the attention of school curriculum specialists in the future as well. In high school, students have reached a stage of development to face and be challenging; to undertake concrete actions, based on knowledge, skills, and values for life.

The hypothesis of the paper lays out the possibility of dealing with the issue in empirical and theoretical aspects, while through the research methodology the answer is given to the posed issue. To achieve the aims and objectives, it is necessary for the actors of the school to be more informed about the contemporary demands of the Albanian market as well as the global market for young programmers, increasing the efforts to include students in the site as much as possible. We reach the conclusion that:

- The programming classes development encourages more students on the site to be more involved in the lessons, it is evident that there is a connection between coding and the subjects of exact sciences such as mathematics, physics, etc. As well as the effect that this way of teaching has on preparing young people to be able to solve problem situations.
- Furthermore, we recommend that, based on the achieved results by the study, the hours of ICT 11 should be doubled, from 36 to 72 hours per year. This would ensure a better absorption by the subject learner but would also be helpful to the teacher.

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