Pair Programming Education Aided by ChatGPT

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***Abstract* - Programming education is generally considered as very challenging for both teachers and their students. Students are in many cases more used to memorizing facts than to adopting a new skill that requires intensive and prolonged learning. Also, programming concepts can be quite abstract and hard to perceive by students. In time, many teaching approaches and aiding tools have been identified, but the challenges of programming education have remained one of important research topics. Rapid development of new technology has resulted in new possible approaches in programming education. In this paper, an overview of challenges in programming education is given, and research results about using pair programming in combination with ChatGPT as an educational aiding tool are presented and elaborated.**

Keywords - pair programming; education; ChatGPT

I. INTRODUCTION

Programming is very important part of future information technology professionals because it promotes problem-solving skills [1] and develops computational thinking, which is important for solving complex problems and developing different strategies in areas unrelated to programming [2; 3].

Since the personal computers for home use in the early eighties of the 20th century have started to be used on a wider scale, there has been an idea of teaching students about programming, and many schools have introduced their students to programming in Basic or Logo [4; 5]. However, despite the increasingly available computers and their use for many other purposes most people consider programming a technical activity suitable for only a small part of the population [4; 6].

Possible reason for the loss of interest in programming lies in the fact that programming languages can be quite difficult to learn, and students have problems even with knowing the syntax and semantics of some programming languages [7]. In addition, programming is in many cases presented through problems that are not related to students' interests or experiences, and it is difficult to encourage and motivate students to invest sufficient energy needed to master programming as a skill.

In today's world, the introduction of programming, as well as the application of information and communication technology (ICT), is considered to be of great educational importance, which is why this part of the education is included in many of the most developed European and world educational curricula on the elementary school level [8]. Furthermore, knowledge of programming, as a part of logical reasoning, has become one of the key competencies that all students should possess, as well as employees in a wide range of professions [9].

In order to make learning programming as easy as possible, and to reduce the gap between the level of knowledge and real-world business requirements, new approaches and innovative ways of teaching programming are being developed in schools, colleges, numerous organizations and non-profit associations. One such approach is a combination of pair programming and ChatGPT as an educational assistive tool.

A. Pair Programming

Pair programming refers to the practice in which two programmers work together, while collaborating on the same design, algorithm, code, and testing. The roles of programmers are mutually divided between the person who writes the code, i.e. the driver, and the person who checks it, i.e. the navigator. In addition, both programmers participate equally in designing the solution. It is definitely necessary to prepare the students for the mentioned tasks so that the results are as successful as possible.

Pair programming has become widely accepted since its inception in the 90s thanks to its advantages over individual programming. In secondary schools, this kind of collaborative learning method [10] proved to be successful, and its potential is still a valid research direction. Some of the more significant advantages compared to independent programming are the production of original code with fewer errors, the code is of higher quality and created in a shorter time compared to an individual programmer, programmers learn from each other, build trust and improve teamwork, brain activity is enhanced [11], and programmers feel happier [12; 13]. It has also been proven that pair programming can have a long-term effect on learning outcomes in other areas as well [14]. Pair programming can be applied to simpler tasks for a shorter, but also a longer period of time.

Unfortunately, despite the numerous mentioned advantages, pair programming is not often used in secondary school education, and the reason for this is reflected in certain shortcomings that primarily relate to the

problem of communication, prior knowledge of the partner, and the assignment of appropriate tasks [15].

B. Artificial intelligence and chatbots

Artificial Intelligence (AI) in its advanced form may have skills that resemble the problem-solving skills, communicating in a natural language, learning, and recognizing situations in the same way as humans do [16], but the main difference between AI and other computer programs is its ability to learn.

AI is today important not only for doing business but for education process as well. Because of this, AI is being included in the modern educational programs as a prerequisite to understand the contemporary world. In STEM education it can play an important role in assisting teachers in their roles as facilitators and assessors of learning which is demonstrated by the possibilities to analyze data about the learning process itself [16].

So, it can be said that emerging technologies have also been transforming ways of teaching and learning. For example, chatbots like Chatsonic and ChatGPT (Chat Generative Pre-trained Transformer) are an AI-based programs with technology that recognizes speech and then responds appropriately, providing personalized learning support using computers, mobile phones, or some other devices.

The interaction between chatbots and students may aid learning using a platform for a new educational paradigm in various scientific fields [17]. As a result, because of the teachers shortage Edwards and Cheok [18] have proposed to aid teaching with robots capable of demonstrating artificial intelligence in practice. Furthermore, Zhao et al. [19] claim that the use of AI-based teaching has a positive impact on students' academic achievement, while Topal et al. [17] believe that chatbots can help with science teaching by improving students' performance. Moreover, according to Kim and Kim [20] teachers' use of an AI-enhanced systems may have a positive effect on STEM students' scientific writing.

Despite all, there is a lack of educational perspectives in AI in education research [21], so researchers concern about the absence of educational theories and models, as found in AI-enabled e-learning research published in the last decades.

Following the above, several research question can be identified:

- How to increase student motivation to learn programming?
- Can pair programming promote student interest in programming?
- Can using ChatGPT make programming education more effective?
- etc.

II. RESEARCH METHODOLOGY

In order to conclude about the motivation of students to learn programming, and effectiveness of pair programming aided by ChatGPT the corresponding research was conducted. 45 science and mathematics high school majors participated in the research.

The research has been conducted in two parts. First part of the research aimed to determine the initial motivation for learning programming and attitude towards pair programming and ChatGPT. The second part of the research aimed to determine the motivation for learning programming and attitude towards pair programming and ChatGPT after students' experience with this learning method and technology.

At the beginning of each class, students filled out questionnaires U1, U2 and U3, which tested their motivation for programming, motivation for pair programming, as well as their attitude and habits of using ChatGPT.

All three questionnaires consist of 6 questions and are based on Likert scale where 1 represents the statement "I do not agree" and 5 the statement "I completely agree".

All created questionnaires are more or less based on Technology Acceptance Model and its principles [22; 23].

Questionnaire U1 consisted of the following 6 questions:

- Q1 - Solving mathematical and logical problems is interesting
- Q2 - Programming is a useful skill
- Q3 - Programming is an interesting skill
- Q4 - Programming is difficult to learn
- Q5 - I want to learn programming
- Q6 - Learning programming is interesting

The following 6 questions are part of U2 questionnaire:

- Q1 - Pair programming is fun
- Q2 - Pair programming helps me learn
- Q3 - Pair programming will result in usable program solution in less time
- Q4 - Programming in pairs will result in a higher quality programming solution
- Q5 - During pair programming I can learn from the other team member
- Q6 - I want to program in pair with someone I know

Finally, the following 6 questions are part of U3 questionnaire:

- Q1 - ChatGPT is an interesting programming tool
- Q2 - I learn faster with ChatGPT
- Q3 - I use ChatGPT for learning
- Q4 - I use ChatGPT to create parts of the program code
- Q5 - I use ChatGPT to create the complete program solution
- Q6 - I feel that I don't need to know how to program because I can create programs using ChatGPT

After completing the questionnaires, students were given certain algorithmic tasks in Python determined by the teaching curriculum in informatics. Students were using pair programming, aided by ChatGPT.

Finally, at the end of the class students filled out the same questionnaires again as at the beginning in order to determine a possible change in perception of learning programming, pair programming, as well as using ChatGPT.

To compare the results of the questionnaires, a depended samples t-test was used because to check if there is a statistically significant difference between results at the beginning and at the end of the research.

III. RESEARCH RESULTS

Firstly, the descriptive statistics is given. As it can be seen in Table I, descriptive statistics for questionnaire U1 and all questions at the beginning and at the end of research shows clear difference and shift in students' perception and attitude.

TABLE I. Descriptive statistics of U1 questionnaire

#Q	Valid	Mode	Median	Mean	Std. Error of Mean	Std. Deviation
Q1	45	4.000	4.000	3.644	0.163	1.090
Q2	45	5.000	5.000	4.178	0.163	1.093
Q3	45	5.000	4.000	3.822	0.178	1.193
Q4	45	3.000	3.000	3.156	0.180	1.205
Q5	45	5.000	4.000	3.711	0.200	1.342
Q6	45	3.000	3.000	3.444	0.176	1.179
#Q	**Valid**	**Mode**	**Median**	**Mean**	**Std. Error of Mean**	**Std. Deviation**
Q1	45	4.000	4.000	3.978	0.147	0.988
Q2	45	5.000	4.000	4.222	0.149	0.997
Q3	45	5.000	4.000	3.956	0.168	1.127
Q4	45	4.000	4.000	3.511	0.190	1.272
Q5	45	5.000	4.000	3.911	0.168	1.125
Q6	45	5.000	4.000	3.933	0.186	1.250

Descriptive statistics for U2 questionnaire is shown in Table II.

TABLE II. Descriptive statistics of U2 questionnaire

#Q	Valid	Mode	Median	Mean	Std. Error of Mean	Std. Deviation
Q1	45	5.000	4.000	4.022	0.167	1.118
Q2	45	5.000	4.000	3.800	0.179	1.198
Q3	45	5.000	4.000	4.133	0.161	1.079
Q4	45	5.000	4.000	3.978	0.157	1.055
Q5	45	5.000	5.000	4.489	0.126	0.843
Q6	45	5.000	5.000	4.400	0.133	0.889
#Q	**Valid**	**Mode**	**Median**	**Mean**	**Std. Error of Mean**	**Std. Deviation**
Q1	45	5.000	5.000	4.222	0.155	1.042
Q2	45	5.000	5.000	4.267	0.150	1.009
Q3	45	5.000	4.000	4.178	0.143	0.960
Q4	45	5.000	4.000	4.111	0.146	0.982
Q5	45	5.000	5.000	4.378	0.140	0.936
Q6	45	5.000	5.000	4.422	0.129	0.866

In case of questionnaire U2 the situation is similar as with U1, except regarding the question Q5 where minimal negative difference can be observed at the end of the research.

TABLE III. Descriptive statistics of U3 questionnaire

#Q	Valid	Mode	Median	Mean	Std. Error of Mean	Std. Deviation
Q1	45	5.000	5.000	4.400	0.144	0.963
Q2	45	3.000	3.000	3.022	0.221	1.485
Q3	45	1.000	2.000	2.333	0.220	1.477
Q4	45	1.000	2.000	2.111	0.196	1.318
Q5	45	1.000	1.000	1.933	0.175	1.176
Q6	45	1.000	2.000	1.956	0.174	1.167
#Q	**Valid**	**Mode**	**Median**	**Mean**	**Std. Error of Mean**	**Std. Deviation**
Q1	45	5.000	5.000	4.444	0.129	0.867
Q2	45	5.000	4.000	3.933	0.172	1.156
Q3	45	5.000	4.000	3.622	0.221	1.482
Q4	45	5.000	4.000	3.689	0.217	1.459
Q5	45	5.000	4.000	3.667	0.229	1.537
Q6	45	5.000	4.000	3.489	0.239	1.604

Descriptive statistics of U3 questionnaire is shown in Table III positive difference can be observed in the case of questions Q3, Q4, Q5, and Q6 at the end of research.

The distribution of the difference between the two related groups regarding questionnaire U1 is shown in Table IV.

TABLE IV. Checking normal distribution (U1)

Questionnaire U1

	Beginning res.	End of res.
Valid	6	6
Mean	3.659	3.918
Std. Deviation	0.346	0.230
Skewness	0.049	-0.979
Std. Error of Skewness	0.845	0.845
Kurtosis	0.570	2.850
Std. Error of Kurtosis	1.741	1.741
Shapiro-Wilk	0.989	0.867
P-value of Shapiro-Wilk	0.987	0.216
Minimum	3.156	3.511
Maximum	4.178	4.222

The distribution of the difference between the two related groups regarding questionnaire U2 is shown in Table V.

TABLE V. Checking normal distribution (U2)

Questionnaire U2

	Beginning res.	End of res.
Valid	6	6
Mean	4.137	4.263
Std. Deviation	0.263	0.119
Skewness	0.298	0.241
Std. Error of Skewness	0.845	0.845
Kurtosis	-1.278	-1.315
Std. Error of Kurtosis	1.741	1.741
Shapiro-Wilk	0.945	0.959
P-value of Shapiro-Wilk	0.704	0.812
Minimum	3.800	4.111
Maximum	4.489	4.422

The distribution of the difference between the two related groups regarding questionnaire U3 is shown in Table VI.

TABLE VI. Checking normal distribution (U3)

Questionnaire U3

	Beginning res.	End of res.
Valid	6	6
Mean	2.626	3.807
Std. Deviation	0.958	0.344
Skewness	1.658	1.604
Std. Error of Skewness	0.845	0.845
Kurtosis	2.446	2.612
Std. Error of Kurtosis	1.741	1.741
Shapiro-Wilk	0.792	0.838
P-value of Shapiro-Wilk	0.049	0.124
Minimum	1.933	3.489
Maximum	4.400	4.444

By checking the normality of the distribution in the Table IV, Table V, and Table VI, it is clear that values of skewness are between -2 and +2, but the kurtosis values are not.

Descriptive plots that show the means and standard deviations for each group of results are shown in Figure 1, Figure 2, and Figure 3. It can be observed that all means are higher at the end of the research.

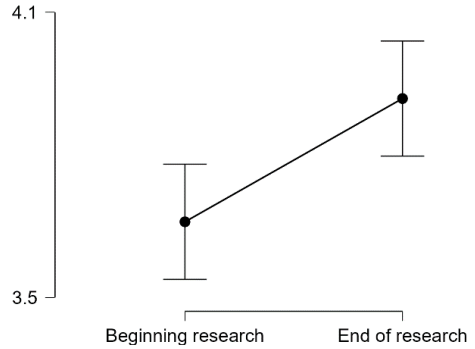

Figure 1. Graphical representation of means in U1 questionnaire

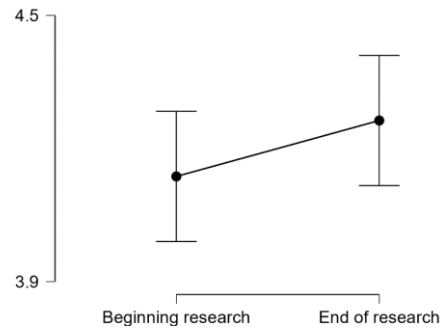

Figure 2. Graphical representation of means in U2 questionnaire

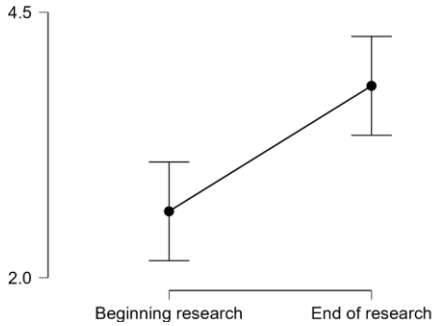

Figure 3. Graphical representation of means in U3 questionnaire

In order to further conclude about obtained research results, a paired samples t-test has been performed.

The respondents on average agreed more (p=0.050) with the statement "Solving mathematical and logical problems is interesting" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.98, SD = 0.988) than before (M = 3.64, SD = 1.090).

The respondents on average agreed more (p=0.015) with the statement "Learning programming is interesting" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.93, SD = 1.250) than before (M = 3.44, SD = 1.179).

The respondents on average agreed more (p=0.003) with the statement "I learn faster with ChatGPT" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.93, SD = 1.156) than before (M = 3.02, SD = 1.485).

The respondents on average agreed more (p=0.000) with the statement "I use ChatGPT for learning" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.62, SD = 1.482) than before (M = 2.33, SD = 1.477).

The respondents on average agreed more (p=0.000) with the statement "I use ChatGPT to create parts of the program code" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.69, SD = 1.459) than before (M = 2.11, SD = 1.318).

The respondents on average agreed more (p=0.000) with the statement "I use ChatGPT to create the complete program solution" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.67, SD = 1.537) than before (M = 1,93, SD = 1.176).

The respondents on average agreed more (p=0.000) with the statement "I feel that I don't need to know how to program because I can create programs using ChatGPT" after engaging in the pair programming and ChatGPT assisted programming education (M = 3.49, SD = 1.167) than before (M = 1.96, SD = 1.167).

IV. CONCLUSION

Programming education is challenging for both teachers and students. The need for programming experts makes programming education an important factor of continuous information systems development.

In this paper, an overview of some of challenges in programing education has been given, and research results of using pair programming and ChatGPT as an assistive educational and programming tool have been presented.

Based on obtained research results it can be concluded that there is a positive difference in students' motivation for programming and using ChatGPT before and after conducted research, but not in the pair programming domain. The reasons can be numerous, and this will part of the further research efforts.

Another part of the future research will be different approaches towards using ChatGPT as an educational tool, and identifying possible challenges that education systems will have to deal with regarding artificial intelligence and other new technologies.

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