

A Study of The Effects of Short-Term AI Coding Course with Gamification Elements on Students' Cognitive Mental Health

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Abstract – The objective of this research is to study the effect of short-term AI coding course with gamification elements on primary school students' cognitive skill and mental health. The proposed gamification coding activities was designed to help students in comprehending the coding concept, which is often seen as challenging. For 8 weeks, 43 primary school students aged 7 to 12 were randomly divided into a control group and an experimental group. The experimental group learnt AI and basic coding, whereas the control group just learned basic coding. According to the results, students' cognitive skills and mental health have improved.

Keywords – Mental health, AI coding, block-based coding, gamification elements, elementary school student.

1. Introduction

Games can influence a person's developmental, cognitive, emotional, social, and language growth [1]. According to psychoanalytic researcher, it can improve a child's anxiety by removing the pressure and tension of everyday life.

It helps in the emotional development of children by assisting them in dealing with difficult situations. Many different abilities, including self-regulation, may be honed by gamified approaches. It helps people develop healthier routines and perspectives [2], [3]. Gamification is the process of making user engagement fun instead of a serious game. It can help students learn how to code, and the activities make it fun. The students will feel less pressure than with traditional ways of learning, which helps them learn better [4], [5]. Gamification has become more popular in teaching and learning over the recent years. It is suggested that game elements such as points, badges, and leader boards be used to increase interest [6].

Learning to code with AI may help students enhance their problem-solving abilities, system design skills, and comprehension of human behavior based on computer science ideas [7]. When AI lessons are offered to kids at the right age, they have a great chance to learn more about how AI works. Following that, concerns for students' mental and emotional health should be highlighted throughout the online learning process [8]. The goal of gamification in education is to make learning more fun, and it goes beyond traditional ways of learning. The gamification of learning could help us come up with new, educational, and fun content.

2. Related Work

This section shall discuss the related works related to the importance of cognitive skills, benefits of short-term coding course, importance of mental health and gamification approach in learning coding.

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2.1. Importance of Cognitive Skills

Cognitive skills are mental skills that are employed in the process of acquiring new knowledge, solving problems, and determining the best solution to a problem. As students get better at integrating ideas and absorbing new information, their academic achievement increases. Bloom's taxonomy is a framework for studying and mastering a subject cognitively. It encourages high-level thinking through developing low-level abilities. It is used in many computers' science course [9]. It found that cognitive skillsets including problem solving, abstract thinking, accurate memory, and language understanding may preserve mental health from the negative impacts of stress and violence [10]. Those with high levels of cognitive flexibility are more prone to analyze problems from multiple perspectives and easily adapt their ideas which leading to increased satisfaction with life, general self-perception, and mental wellbeing [11],[12].

Raven's Standard Progressive Matrices (RSPM) is a non-verbal test that can be applied in any geographic or academic context. It was designed for ages 6 to 16. It is a test of observation and critical thinking abilities that provides insight into someone's ability to observe, solve problems, and learn. The scores are unaffected by language or ethnic background. The test consists of 60 matrices divided into five groups of 12. The participants need to find the missing component that was required to complete a larger pattern chosen from six to eight options offered in each question. The answers were graded using the specified marking scheme at the end of the test [13].

2.2. The Benefits of Short-Term Coding Course

Previous research has explored the impact of coding course on children, with most of the results showing that the study may build a variety of skills that are beneficial now and in the future. Coding offers positive effects such as enhancing logical reasoning, independent learning, problem-solving, creativity, collaboration, and communication [14]. They investigate the effect of a coding course on the decision-making and cognitive capacities of preschool children aged 4–5 years. By applying the group pretest–posttest design approaches, both groups are tested before and after the experiment. There was an increase in non-verbal cognitive ability among students learning coding, but there was not so much difference in students' problem-solving ability. The authors recommend that future researchers investigate how age differences, curriculum, and problem-solving methods, as well as the use of diverse coding environments, may impact students'

capacity to work and learn. In [15], the authors examine how robotics activities and coding activities affect preschoolers' problem-solving skills and creativity. This study has been designed as a quasi-experimental investigation with pretest–posttest control groups for children aged 5 years old. The robotics instruction significantly enhanced children' problem-solving and creativity skills. According to [16], the authors investigate how code learning impacts primary school students' writing skills. The study was designed as mixed method where the quantitative and qualitative data are collected. The findings demonstrate how learning to code through Google's CS First Storytelling classes may help students develop their story writing stamina and abilities. The authors in [17] conducted a beginner coding program for a primary school student to improve their life skills and get used to learning online in response to Covid-19. The student was separated into four groups. In the study, participants who participated between six and eight times had higher life skills scores than those who participated between two and four times. The life skills such as critical thinking, self-awareness, empathy, communication, problem solving, creative thinking, interpersonal relationship, decision making, managing stress and emotions are improved. The author suggests that future study should focus on developing basic coding course such as conditional statements which are the basic of coding as well as the research should not be confined to students in grades 5 and 6.

In [7], the authors carried out the coding program to evaluate AI learning using a mixed methods approach sequential exploratory design. The study was done on 16 and 17-year-old students. The result verifies that 97.5 percent of the student enjoy the coding program and agree the speech synthesis and ML are easy to use. The coding activities can help students enhance their mathematical thinking skills [18]. The coding activities were tested to student aged 4 to 5 years old using quasi-experimental design. Each coding activities project focuses on a particular aspect of mathematical reasoning, allowing students to learn these abilities through computer programming. Numerous authors that teach coding activities suggest doing research on students of varying ages, and demographic characteristics to highlight the variations that arise [7], [16], [18].

2.3. Importance of Mental Health

Mental health is a way of thinking, regulating emotions and managing behavior. Since mental disorders tend to emerge throughout childhood, it is crucial to recognize and treat them early [19]. One's mental health might be impacted by life changes like

relocating, starting a new school, or welcoming a new sibling. While some kids really like it, others struggle with anxiety. According to [20], depression has a significant impact on cognitive functioning and is a severe mood disorder defined by a wide range of unpleasant emotions and abnormal behaviors. Next, anxiety is a state of mind characterized by emotions of tension, danger, and worrisome thoughts. Anxiety has a negative impact on students in the classroom where because of their anxiousness, students are more likely to have learning challenges and a lack of problem-solving abilities. The difference in stress a person endures is determined by their daily situations [21]. Ramli utilized a simplified version of the DASS-21 to screen for mental illness. Most researchers believe the DASS-21 short version is more appropriate for research than the complete version [8]. It is used to measure a person's negative emotional states such as stress, anxiety, and depression. Participants should rate each scale depending on how often they encountered the symptoms. On a four-point Likert scale, responses range from 0 (never) to 3 (very often) [22].

According to [23], mental health was discovered to be a powerful predictor of future academic success, with students in the first and third grades who improved their mental health surpassing those who did not improve or deteriorated their mental health. The authors in [22] investigate the impact of Progressive Muscle Relaxation (PMR) psychological skill training on emotional stress in netball players aged 10 and 11. The results demonstrate that anxiety is a significant contributor to the emotional stress experienced by 10 and 11-year-old netball players, and that stress and anxiety are interrelated.

There has been a global health crisis causing the education industry to move online due to Covid-19 [24]. Despite the pandemic, students had good mental health and were motivated to study online. Online education is useful for gaining knowledge and strengthening practical and communication skills since students can complete task and engage with teachers [25]. Since mental health a relatively new issue in the context of education, there are insufficient studies on the emotional state of students [8]. As a result, this study was carried out to address the gap in the existing literature where insufficient studies have investigated at the mental health of primary students while learning to code.

2.4. Gamification Approach in Coding Activities

The students can benefit from gamification in terms of engagement, programming knowledge, motivation, and attitude [26]. The two main types of gamifications are Structural and Content gamification. Structural gamification is when game

elements like points, levels, badges, leaderboards, and rewards are used in educational settings to motivate students to do activities and stay on track with learning goals. Content Gamification is the use of game parts, game rules, and game-like thinking [27]. In addition, gamification involves making changes to the material, such as adding storylines, challenges, curiosity, riddles, and characters [6].

Using gamification to get student involved in solving math problems can help them feel less anxious and stressed about math. It makes studying more fun and keeps you from getting bored. It also lets self-awareness, self-adjustment, and self-learning grow quickly [28], the author used gaze similarity to determine the level of interest in the coding task. The students may find creating games with robots interesting. Using a collaborative coding method, students also make decisions and convey their knowledge collectively, which stimulates learning. In agreement with [29], the authors created an approach using board games to improve the AI-learning motivation of elementary school students. The 97 percent satisfaction and comprehension of the proposed teaching approaches demonstrates that AI education could increase students' interest in AI and positive motivation to study. The gamification strategy enables students to get a deeper understanding of programming and become more motivated to learn it. However, the study had implemented a 3-week coding course duration and a longer duration was recommended to produce more promising outcomes [30].

3. Methodology

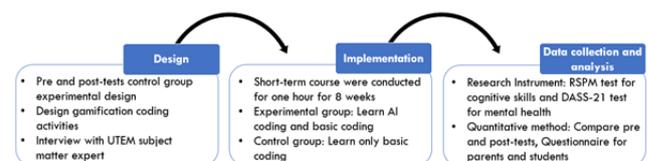


Figure 1. The process flow for conducting the short-term AI coding course with gamification elements

3.1. Phase 1: Design

The relevant articles were explored using reliable sources, and a literature review was conducted. It provides an overview of current information and how the previous researcher conducted the short-term coding course. It enables the identification of relevant concepts as well as loopholes in existing studies. The proposed coding activities was designed based on previous papers and Stempedia Quarantine Special Course [32], [33]. Then, an interview with a gamification subject matter expert from Universiti Teknikal Malaysia Melaka (UTeM) was conducted to obtain feedback and verify the proposed coding activities.

3.2. Phase 2: Implementation

The course has been promoted through social media platform, and students who wish to participate may register for it. The participants were from primary schools in different states. A total of 43 participants (20 in the experiment group and 23 in the control group) were enrolled, ranging in age from 7 to 12 and from various demographic backgrounds. In this study, the independent variable is a short-term AI coding course, while the dependent variable is mental health. Since the proposed study utilized a pre-test post-test control group experimental design, the students were randomly assigned to the control and experimental groups. In both experimental and control groups, short-term course was conducted for one hour every Saturday and Sunday for 8 weeks. The students who are unable to attend class on the required day and time are required to submit works that was discussed in class and recorded at each lesson. The experimental group will learn basic coding and AI using gamification elements, whereas the control group focused just on learning basic coding using gamification elements.

3.3. Phase 3: Data Collection and Analysis

Data was collected both before and after the short-term coding course started. The pre- and post-tests are measuring instruments for assessing the mental health of primary school students using the DASS-21. The gamification coding activities are expected to have a positive influence on student mental health. The result of both pre and post-tests will be compared and analyzed to see if there are significant effect on scores between the two groups. The test was carried out based on the availability of students and researcher.

4. Result and Discussion

This section presents the design of proposed coding activities based on literature review and subject matter expert feedback. Cognitive and mental health score variations of the participants in this study are also presented and discussed.

4.1. Proposed Coding Activities

Several lessons have been integrated into this proposed coding activities after reviewing numerous instances of coding activities from previous studies. In addition, the coding activities in this course are also adapted from the Stempedia Quarantine Special Course [32] and modified by adding some lessons on gamification elements. The proposed coding activities also has been validated by subject matter

expert from UTeM. Figure 2 shows the description of each coding activities performed during the short-term course.

Coding Activities	Description
A1: Card Animation	Dialogue with Tobi: Make the Sprite communicate by using conversation.
	Play a sound: To make the Sprite sound, add, choose, or create their own sound from Pictoblox.
	Change Sprite Size: Change the size of the sprites to make them smaller or larger.
	Change colour: Change the Sprite's colour, as well as the backdrop.
	Make Tobi Walk: Try out the loop function and make Tobi walk left to right
A2: Arithmetic operator	Students learn operators like greater and smaller than, equal to, and smaller than. Then combining the arithmetic operator with variables coding
A3: Variables	The student will learn how to create a dialogue using variables.
	Dialogue with two Sprites: The student will learn how to make narrative story between many sprites Sum of two numbers: Calculate the sum of the values between the two input variables. Variables and operators are used in combination.
A4: If else	The student will create a dialogue that will need them to fill in the blanks. The student attempts to input the correct or wrong answer, and Sprite responds with whether the value entered is correct.
	Calculating Grades: Using the if else and arithmetic operators, create a subject marks grade where the Sprite will show the grade if the student enters the subject marks.
Simple Game Introduction	The learner will learn how to create a basic game such as "Catch the Star", "Catch the Apple", and "Chick Game". The soccer game in which the Sprite tells a short storyline
A5: Game	Make a level up scoring game to catch the star and apple by combining the coding learned. The chick game will allow the student how to make Sprite jump and avoid the obstacles.
A6: Object Recognition	Use software extensions and combination with the concepts of variables, loops, and operators.
A7: Human Body Detection	Gesture-controlled space battle game: Control the game using fingers with score and timer. The student will be informed of their progress with feedback points, such as whether they have reached level 1 or the following level. Combination with variables, loops, and operators coding
A8: Face Recognition	Face Expression: Using a computer to learn human expression. Combination with the loops concept
	Face filters: Create a filter such as crown, spectacles, or animal.
A9: Speech Recognition	The student will attempt to switch on or off the light bulb using voice. Use combination with the concepts of loops, and operators.
A10: Machine Learning	The student will teach the computer to identify between those who are wearing masks and those who are not. Combination with the loops concept
	Driver's Hand Signals: Control the movement of the vehicles using hand. When the vehicles arrive at their destination, as well as when they arrive at the game's point to point, the student will receive a score
	Yoga Activity: When the student does the correct yoga pose, their score will be increased.
	Apple game: As the student catches the apple, the game's score increases, and the game ends when the timer runs out.

Figure 2. Description of coding activities performed during the short-term AI coding with gamification elements

4.2. Results and Discussion

The resulting data was collected and evaluated quantitatively using the Wilcoxon Signed Rank Test to evaluate the effectiveness of the experiment and control groups using the software Statistic Package for the Social Sciences (SPSS) version 25.

4.2.1. The analysis of Wilcoxon signed-rank test results for Raven's Standard Progressive Matrices (RSPM)

Table 1 shows the RSPM test scores had significantly changed before and after the course, with a statistical significance of $p < 0.05$ and $z = -3.624$. It is clear from the statistics below that the AI coding course had a positive impact on students'

cognitive growth, as shown by a P value of $0.000 < 0.05$. RSPM scores of 17 out of 20 students have been successfully increased whereas three students whose cognitive abilities have not changed. The percentage of students who improved from pre-test to post-test in the experimental group rose from 53 percent to 64 percent. This suggests that students have improved their ability to observe, solve problems, and learn by answering more questions correctly based on their enhanced ability to watch and think critically.

Table 1. Wilcoxon signed-rank test findings for the experiment group's RSPM test scores before and after the course

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	20	39.40	7.646	24	54
Posttest	20	45.95	5.698	35	55
Ranks					
Posttest–pretest	n	Rank mean	Rank total	z	P
Negative rank	0 ^a	.00	.00	-3.624 ^b	.000
Positive rank	17 ^b	9.00	153.00		
Equal	3 ^c				

Table 2 shows that the RSPM test scores had significantly changed before and after the course, with a statistical significance of $p < 0.05$ and $z = -2.897$. It was observed that 18 students over 23 reported have increased their RSPM scores by 43 percent to 56 percent. However, five students did not increase their cognitive skills at all. In fact, it was lower than the previous score, but according to the percentile indicated they are still in the same percentile level, despite the lower score. So, it can be concluded that their cognitive skill was remained unchanged.

Table 2. Wilcoxon signed-rank test findings for the control group's RSPM test scores before and after the course

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	23	35.43	9.685	13	51
Posttest	23	41.83	10.192	13	57
Ranks					
Posttest–pretest	n	Rank mean	Rank total	z	P
Negative rank	5 ^a	8.60	43.00	-2.897 ^b	.004
Positive rank	18 ^b	12.94	233.00		
Equal	0 ^c				

4.2.2. The analysis of Wilcoxon signed rank test results for students in the control group on the Depression, Anxiety, and Stress Scale 21 (DASS-21)

Table 3 demonstrate there are no statistically significant changes between the pre- and post-experiment levels of depression in the control group students. The post-test result in DASS-21 should be lower than the pre-test score. Only 6 students were able to see a decrease in their depression score over this course. While 8 students have increased their levels of depression, 9 have remained the same. Since p is greater than 0.05, SPSS validates the null hypothesis which the difference between pre- and post-test medians is zero.

Table 3. Wilcoxon signed-rank test findings for the control group's depression test scores

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	23	1.48	1.997	0	8
Posttest	23	1.87	2.418	0	9
Ranks					
Posttest–pretest	n	Rank mean	Rank total	z	P
Negative rank	6 ^a	7.42	44.50	-.506 ^b	.613
Positive rank	8 ^b	7.56	60.50		
Equal	9 ^c				

Table 4 shows that only 12 students were reported to have reduced their stress score after participating in the course. While 9 persons have increased their levels of stress, 2 have remained the same. With $z = -0.667$ and $p > .05$, the analysis findings show that there are no statistically significant changes between the pre- and post-experiment levels of stress in the control group students. Given that $p > 0.05$, SPSS verifies the null hypothesis that the difference between pre- and post-test medians is zero.

Table 4. Wilcoxon signed-rank test findings for the control group's stress test scores

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	23	4.83	2.406	0	9
Posttest	23	4.57	4.176	0	16
Ranks					
Posttest–pretest	n	Rank mean	Rank total	z	P
Negative rank	12 ^a	11.21	134.50	-.667 ^b	.505
Positive rank	9 ^b	10.72	96.50		
Equal	2 ^c				

Table 5 shows that only 8 students were able to reduce their anxiety levels after participating in this group. It was revealed that 13 students have increased their levels of anxiety score, while there has been no change in score for 2 students. It is clear from the results of the study that the anxiety levels of the control group students did not vary statistically significantly between pre- and post-test, with $z = -.877$ and $p > .05$. SPSS confirms the null hypothesis that there is no change between the pre- and post-test medians since p is larger than 0.05.

Table 5. Wilcoxon signed-rank test findings for the control group's anxiety test scores

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	23	2.22	2.295	0	7
Posttest	23	2.65	2.964	0	10
Ranks					
Posttest –pretest	n	Rank mean	Rank total	z	P
Negative rank	8 ^a	11.31	90.50	-.877 ^b	.380
Positive rank	13 ^b	10.81	140.50		
Equal	2 ^c				

4.2.3. The analysis of Wilcoxon signed rank test results for students in the experimental group on the Depression, Anxiety, and Stress Scale 21 (DASS-21)

Table 6 shows that there were statistically significant variations in the stress test scores of students in the experimental group before and after the short-term course, with $z = -3.646$ and $p < .05$. The post-test score should be lower than the pre-test score to demonstrate that this test has a statistically significant difference before and after the short-term course. 17 students were able to lessen their stress levels after taking this course. While 3 students have stayed constant. Since p is smaller than 0.5, SPSS rejects the null hypothesis that the median differences between the pre- and post-test are zero. Hence, this shows that students' mental health has improved in terms of the stress aspect.

Table 6. Wilcoxon signed-rank test findings for the experiment group's stress test scores

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	20	8.80	3.861	3	16
Posttest	20	6.10	3.194	1	13
Ranks					
Posttest –pretest	n	Rank mean	Rank total	z	P
Negative rank	17 ^a	9.88	168.00	-3.618 ^b	.001
Positive rank	1 ^b	3.00	3.00		
Equal	2 ^c				

Negative rank	17 ^a	9.00	153.00	-3.646 ^b	.000
Positive rank	0 ^b	.00	.00		
Equal	3 ^c				

As indicated in Table 7, the pre- and post-test anxiety levels of the experimental group students differ statistically substantially, with $z = -3.543$ and $p < .05$. The result shown that 16 students were able to reduce their anxiety while 4 students' anxiety scores were unchanged. As a result, students' anxiety levels have decreased, indicating that their mental health has improved in terms of the anxiety aspect.

Table 7. Wilcoxon signed-rank test findings for the experiment group's anxiety test scores

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	20	6.75	5.310	1	19
Posttest	20	3.90	3.932	0	14
Ranks					
Posttest –pretest	n	Rank mean	Rank total	z	P
Negative rank	16 ^a	8.50	136.00	-3.543 ^b	.000
Positive rank	0 ^b	.00	.00		
Equal	4 ^c				

After completing this short-term course, 17 participants were found to have a lower post-test score, this suggests they had successfully reduced their depression level. It has been found that 1 student have had a rise in their depression score. Only two students remain unchanged. SPSS rejects the null hypothesis that the post-test median differences are zero. Thus, students' mental health has improved, showing a lower degree of depression.

Table 8. Wilcoxon signed-rank test findings for the experiment group's depression test scores

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	20	5.90	4.424	0	14
Posttest	20	3.10	3.161	0	10
Ranks					
Posttest –pretest	n	Rank mean	Rank total	z	P
Negative rank	17 ^a	9.88	168.00	-3.618 ^b	.001
Positive rank	1 ^b	3.00	3.00		
Equal	2 ^c				

To visualize the comparison of each student's cognitive scores, depression, anxiety, and stress for the control and experimental groups more clearly, a graph has been constructed. Figure 3 compares pre- and post-test cognitive performance and depression levels for the control group. 26 percent of the students showed improvement in their depression after participating in control group.

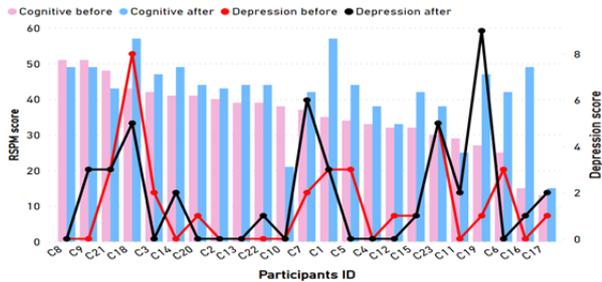


Figure 3. Comparison of student depression levels in the control group before and after participation in the short-term course

Figure 4 compares pre- and post-test cognitive performance and anxiety levels for the control group. Following completion of this course, 35 percent of students reported an improvement in their anxiety levels.

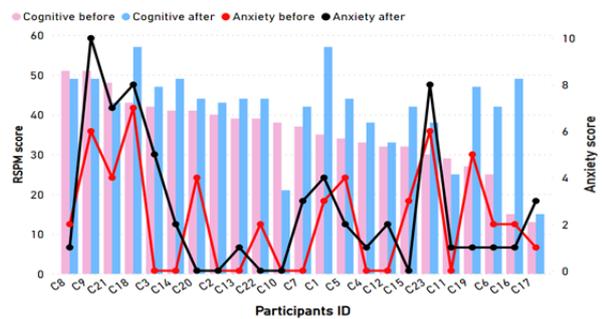


Figure 4. Comparison of student anxiety levels in the control group before and after participation in the short-term course

Figure 5 compares pre- and post-test cognitive performance and stress levels for the control group. The findings indicates that 52% of students were able to lessen their stress levels after completing the short-term course.

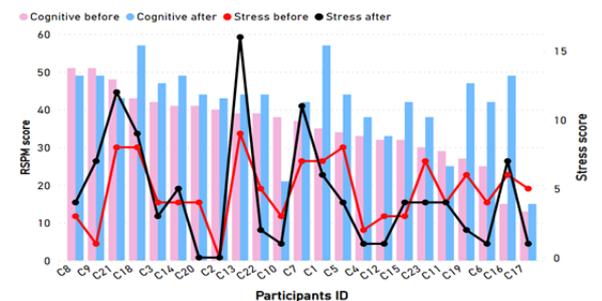


Figure 5. Comparison of student stress levels in the control group before and after participation in the short-term course

Figure 6 compares pre- and post-test cognitive performance and depression levels for the experiment group. 85 percent of the students were able to lessen their depression levels in compared to before taking the course.

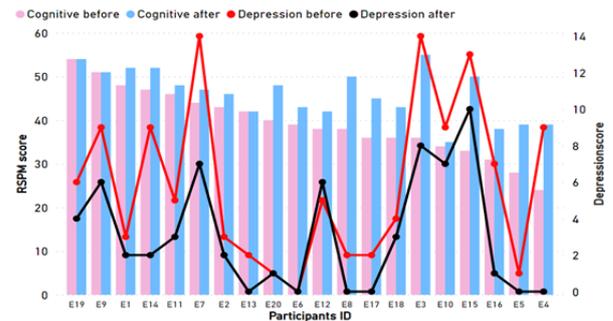


Figure 6. Comparison of student depression levels in the experiment group before and after participation in the short-term course

Figure 7 compares pre- and post-test cognitive performance and anxiety levels for the experiment group. 80 percent of students reduced their anxiety after taking the course.

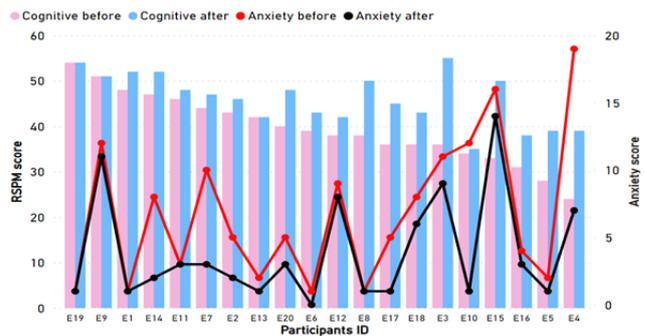


Figure 7. Comparison of student anxiety levels in the experiment group before and after participation in the short-term course

Figure 8 compares pre- and post-test cognitive performance and stress levels for the experiment group. 85 percent of students (17 out of 20 students) were able to reduce their levels of stress after participation in the short-term course.

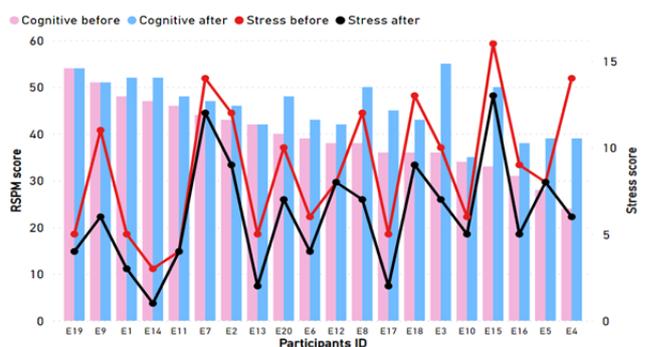


Figure 8. Comparison of student stress levels in the experiment group before and after participation in the short-term course

85 percent of students in the experiment group and 78 percent of students in the control group have improved their cognitive skills. When comparing the two groups' mental health, it was found that 85 percent of the students in experimental group's students showed considerable improvement in their depression score, whereas just 26 percent of the students in control group did so. The results demonstrate that 80 percent of students in the experimental group report reduced anxiety scores, whereas only 35 percent of students in the control group report less anxiety scores. Finally, students in the experimental group report lower levels of stress than those in the control group with 85 percent and 52 percent respectively. This demonstrates that a short-term AI coding course with gamification elements have positive influence on primary students' cognitive skill and mental health.

5. Conclusion

As a student's early education might affect their future achievement, it's important to offer AI-based learning experiences for elementary school students. AI is increasingly becoming a critical resource for boosting STEM fields [31]. Although there has been some study of AI education at the elementary school level, most efforts have been focused on teaching AI at the higher level [32]. Gamification may help educators design lessons that are both highly effective and very interesting for their students. According to the findings, students in the experimental group demonstrated significant differences from those in the control group. In comparison to basic coding with gamification elements, AI coding with gamification elements improves students' mental health. To sum up, the key contributions of this paper are the future researcher may use the study as reference to investigate on other skills or changes in students' academic performance after learning AI coding. SWEBOOK 3.0's coding considerations encourage adopting block-based coding to simplify complicated statements. Hence, the proposed coding activities may enhance student engagement and boost the motivation of primary students to learn AI coding.

For future improvements, the study can be enhanced with implementing a coding assessment at the end of each lesson, training them to participate in the competition would be a practical method to enhance their coding skills. Next, the proposed coding activities will be used to investigate whether they may improve academic performance, such as subject examinations, in STEM-related disciplines.

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