Research Article

Comparative Analysis of GitHub Copilot and ChatGPT in Web Application Development: An Experimental Study

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Abstract:

Nowadays, the artificial intelligence has been rapidly developed and with this development has initiated the transformation of web development by changing the way students deal with code, problem solving and soft skills. The key innovations in this changing are AI tools like GitHub Copilot and ChatGPT which provides intelligent assistance in boost the productivity and learning. The GitHub Copilot is created by GitHub in collaboration with OpenAI, and it is integrated into Visual Studio Code, while ChatGPT is also created by OpenAI, but it facilitated interactive communication through chat and code explanation. Although, several studies treated the AI Tools in education especially ChatGPT but there is limited research comparing these two tools in web development tasks. This experimental study treats the usage of AI tools by students in web application development to show the impact on their learning, development and soft skills through a comparative analysis. Findings suggest both AI Tools integration in educational settings in terms of code generation, but in task completion ChatGPT is slightly faster than GitHub Copilot. While GitHub Copilot was found with stronger impact in collaboration, both tools are equally in critical thinking and adaptability. Based on these findings, this study provides recommendation for integration AI Tools in curriculum design and teaching strategies in computer science education.

1. Introduction

The coding practices has changed by integration of artificial intelligence tools like GitHub Copilot and ChatGPT in environments of web application development by providing new ways how students understand programming and deal with soft skills. GitHub Copilot is developed by GitHub in collaboration with OpenAI, it is offered in different plans like: Individual, Business and Enterprise. For verified students, teachers and maintainers of open-source projects the GitHub Copilot Individual is Free [1]. The GitHub Copilot is integrated directly into Visual Studio Code. It offers in real-time the code suggestions, automate routine coding task and offer code chat. While, the ChatGPT is also developed by OpenAI, it offers code generation, problem solving and code concept explanation. It is not integrated in integrated development environments (IDEs), but it is as conversation agent which allow to interactively communication through chat [2].

Based on conducted related research, several studies explored AI tools and their potential in educational settings like enhancing technical and soft skills [16, 18]. According to Zhang et al. (2023) GitHub Copilot is attractive for developers of different level of experience because it reduces the cognitive load, and it is efficient on coding tasks. Meanwhile, the authors Biswas (2023) and Wermelinger (2023) treated ChatGPT usage, they shown ChatGPT potential on supporting students on understanding development (programing) concept and problem- solving activities in their collaboration.

Although, there is limited research in comparison of AI tools like GitHub Copilot and ChatGPT in the context of web application development, particularly from the students' perspective and experiences before and after experiment with these tools. Even if, the authors Strzelecki (2024) and

Hou et al. (2024), have treated the usage of ChatGPT in higher education but they did not compare AI tools like GitHub Copilot and ChatGPT while. our study aims to fill this gap by investigating the perspective of students who used both GitHub Copilot and ChatGPT in web development tasks. Thus, our study goes beyond pre- and post-surveys, incorporating experimental study which aims to assess and compare the impact of AI Tools on students` learning, development, and soft skills in the context of web application development through eight research objectives [20, 24].

This study offers a valuable result which are related with practical application of AI Tools in web development task in Higher Education Institution, highlighting potential of these tools in supporting students in learning, development and soft skills [32, 33], which are mandatory for modern web application development. Moreover, based on study experience it aims to provide recommendations for the integration of AI Tools in curricula of Study programs in Higher Education Institutions.

1.1. Research Objectives

This study aims to assess and compare the impact of AI Tools on students` learning, development, and soft skills in the context of web application development through the following research objectives:

1. Comparison of GitHub Copilot and ChatGPT on task completion time by students.
2. Assessing and comparing of GitHub Copilot and ChatGPT on the quality of code produced by students.
3. Evaluating and comparing GitHub Copilot and ChatGPT on error rates of developed code by students.
4. Gathering the qualitative feedback of students who experienced the usage of GitHub Copilot and ChatGPT during the development process.
5. Identifying the different student's perspective on how GitHub Copilot and ChatGPT supports their learning and development.
6. Exploring the impact of GitHub Copilot and ChatGPT on problem solving abilities of students.
7. Exploring the impact of GitHub Copilot and ChatGPT on soft skills like as: critical thinking, collaboration, and adaptability.

8. Providing recommendations for usage of GitHub Copilot and ChatGPT in educational settings based on this study.

This study contributes to usage of AI Tools like GitHub Copilot and ChatGPT from students to show the impact on enhancement or hinder of students' development in the field of web application development. Additionally, it also led the implication of curriculum design and teaching strategies in computer science education.

2. Material and Methods

The most appropriate research method for this study is the mixed methods because of the nature of research objectives related to experimental study [3, 4, 5]. The mixed methods allow data collection, analysis, and integration of the qualitative and quantitative research to answer the research objectives through interpretation of the results for generating knowledge [6, 7]. In the context of using a mixed-method approach, the Sequential Exploratory Design (QUAL→ Quan) is employed because it gives priority to the qualitative aspects of the study, then the qualitative components are followed by the phase of quantitative data collection and analysis with the aim of increasing the generalizability of the findings [9, 10, 11]. Moreover, to address the research objectives is applied the experimental research design [8], specifically the Control Experiment. In this experiment, students are assigned in one of two groups:

- Students who complete the tasks in web application development using GitHub Copilot.
- Students who complete the tasks in web application development using ChatGPT.

Some of metrics used for evaluation are task completion time, code quality, and error rates. Also, the students will be surveyed to provide the feedback with valuable information on gathering the qualitative insights from their experiences with each tool during this study. Considering that the soft skills are also essential for success in software development will be evaluated also critical thinking, collaboration, and adaptability.

Combination of students' feedback before and after experiment, the study aims to provide a comprehensive view about impact of AI tools in the students' learning and development including the soft skills.

In the following are shown the research steps of experiment and students` feedback related to research objectives:

1. *Pre-Used AI Tools Survey: 108 Students completed an online google form survey*

prior to the experiment to gather basic information on their experience, expectation, and preferences about AI Tools

2. *Experiment phase – Used AI Tools: 107 Students completed an experiment with selected AI Tools to finish a task of development of web application with these functionalities: Signup form, Signing form and student catalog.*

3. *Post-Used AI Tools Survey: 107 Students completed an online google form survey*

post to the experiment to gather information on their experience with selected AI Tool.

These steps ensure a systematic process, starting from gathering baseline information from the students before the experiment to collecting feedback afterward, to understand the impact of AI tools on their learning, development, and soft skills. The collected data from surveys were analyzed using SPSS [12]. In the following is shown also the figure of this study methodology:
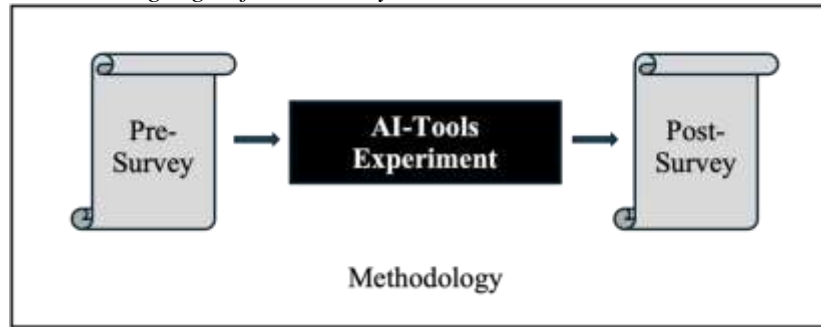

Figure 1 *Methodology*

In this study are involved second- and third-year students from the Faculty of Computer Science at Kadri Zeka Public University. The second-year students without experience in web development while the third-year students with experience on web development based on the faculty' curricula.

In the experiment phase and post-used AI tools survey participated 107 students because one of student was withdrawn from the experiment phase due to a technical issue and did not feel safe continuing and is respected its decision.

4. Results and Discussions

This section will provide the results of the addressed research objectives and discussion related to them.

4.2. Results

This subsection will provide the results of the addressed research objectives through mixed methods and experimental study which are derived from qualitative and quantitative data collected and categorized through research steps. Before showing the results per each research objective, are presented the AI Tool preferences by students and reason that motivated them to select one.
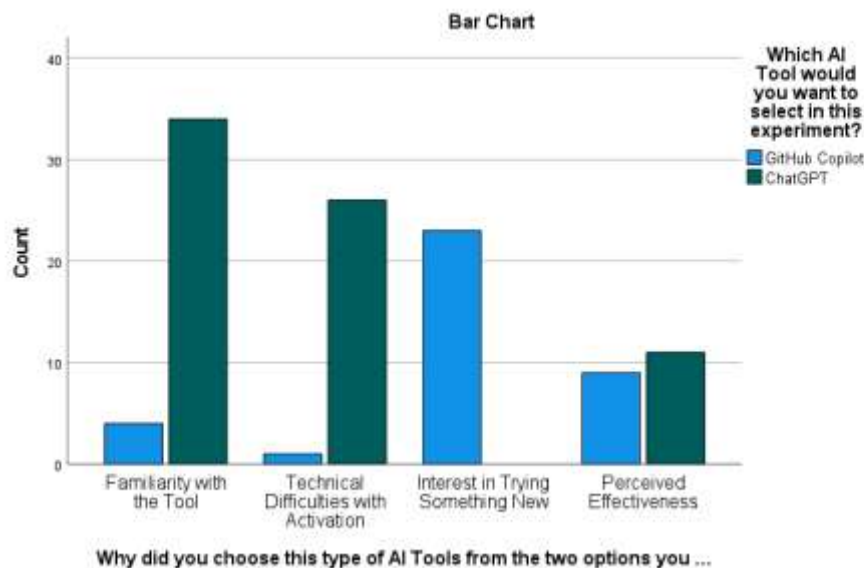

Figure 2 *Students` AI Tools preferences and motivation*

Based on the Figure 2, most of the students has preferred the ChatGPT tool because they are more familiar with the tool and has no technical difficulties with activation like with GitHub Copilot and perceived effectiveness. While the students that preferred the GitHub Copilot were motivated to select it because of their interest in trying something new, which means they did not used it before the experiment. From the students who took part in the experiment phase, 72 students have selected the ChatGPT (42 students of second year and 30 students of third year), and 35 students have selected GitHub Copilot (23 students of second year and 12 students of third year) In the following subsection are shown the results per each research objective.

4.2.1. Comparison of GitHub Copilot and ChatGPT on task completion time by students

In the context of this research objective, the results from the two following questions asked to students after the experiment phase are presented in the figure 3 and 4.

- Did the use of AI tools speed up your task completion? 1. Yes 2. No

- How long did it take them to complete the task (response in minutes)?

The collected data which include categorical and numerical data are analyzed in SPSS through Chi-Square, Fisher Exact and Independent Sample test because of comparison of task completion speed between two groups of students using AI Tools such as GitHub Copilot and ChatGPT.Based on results in figure 3, the "minutes for complete the task" for GitHub Copilot (75.34) was rated slightly higher than ChatGPT (67.35) but this difference was not statistically significant because

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Did the use of AI tools speed up your task completion?	Yes	24	58	82
	No	11	14	25
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.889ᵃ	1	.169		
Fisher's Exact Test				.224	.130
N of Valid Cases	107				

Figure 3 Task completion speed results

Group Statistics

	Which AI Tool would you want to select in this experiment?	N	Mean	Std. Deviation	Std. Error Mean
How long did it take them to complete the task (response in minutes)?	GitHub Copilot	35	75.34	21.029	3.555
	ChatGPT	72	67.35	25.121	2.960

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
How long did it take them to complete the task (response in minutes)?	Equal variances assumed	3.334	.130	1.625	105	.107	7.996	4.919	-1.758	17.749
	Equal variances not assumed			1.728	79.265	.088	7.996	4.626	-1.212	17.203

Figure 4 Task completion speed results in minutes

the p-values in both cases are greater than 0.05 (0.107 and 0.088). This means that also in this case neither AI Tools did not pass each of one in terms of speeding up the task completion in minutes.

4.2.2. Assessing and comparing of GitHub Copilot and ChatGPT on the quality of code produced by students

In relation to this research objective, the results of four following questions asked to students after the experiment phase are presented in the figure 5.

- Do you feel confident at your current level in writing new code? 1. Yes 2. No
- Does have the quality the generated code by GitHub Copilot/ChatGPT? 1. Yes 2. No
- Did you have to significantly modify or correct the AI-generated code? 1. Yes 2. No
- Did the AI tools help you improve your coding structure or style? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of quality of code produced by students of two groups which used AI Tools like GitHub Copilot and ChatGPT.

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Do you feel confident at your current level in writing new code?	Yes	17	40	57
	No	18	32	50
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.461ª	1	.497		
Fisher's Exact Test				.540	.318
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Does have the quality the generated code by GitHub Copilot/ChatGPT?	Yes	28	66	94
	No	7	6	13
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.003ª	1	.083		
Fisher's Exact Test				.114	.081
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Did you have to significantly modify or correct the AI-generated code?	Yes	19	26	45
	No	16	46	62
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.192[a]	1	.074		
Fisher's Exact Test				.096	.058
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Did the AI tools help you improve your coding structure or style?	Yes	26	58	84
	No	9	14	23
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.549[a]	1	.459		
Fisher's Exact Test				.463	.308
N of Valid Cases	107				

***Figure 5** Assessing and comparing of GitHub Copilot and ChatGPT on the quality of code produced by students after experiment*

Based on results in figure 5, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in confidence at their level in writing new code because the p-values in both cases are greater than 0.05. Also, that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in the quality of generated code by AI Tools because the p-values in both cases are greater than 0.05. In the questions related to modification or correcting of AI-generated code and improvement of coding structure or style based on results in figure 5 we conclude that there is no statistically significant difference in both cases because the p-values are greater than 0.05. This means that also in this case neither AI Tools did not pass each of one in terms of quality of code produced by students using them.

If we compare the above results in figure 5 (after experiment) with the following results in figure 6 (before experiments), it is obviously clear that students also before experiments were not confident at their level of writing new code and their ability to debug or optimize existing code. Thus, the usage of AI Tools does not change the quality of code produced by students because there is no statistically significant difference in results.These are the two following questions asked to students before the experiment phase:

- Do you feel confident at your current level in writing new code? 1. Yes 2. No
- Do you think you currently have ability to debug or optimize existing code? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of quality of code produced by students of two groups which used AI Tools like GitHub Copilot and ChatGPT.

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Do you feel confident at your current level in writing new code?	Yes	18	33	51
	No	19	38	57

Total	37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.046[a]	1	.830		
Fisher's Exact Test				.842	.495
N of Valid Cases	108				

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Do you think you currently have the ability to debug or optimize existing code?	Yes	14	21	35
	No	23	50	73
Total		37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.758[a]	1	.384		
Fisher's Exact Test				.395	.255
N of Valid Cases	108				

Figure 6 *Assessing and comparing of GitHub Copilot and ChatGPT on the quality of code produced by students before experiment*

Based on results in figure 6, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in confidence at their level in writing new code because the p-values in both cases are greater than 0.05. Also, there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in their ability to debug or optimize existing code because the p-values in both cases are greater than 0.05.

4.2.3. Evaluating and comparing GitHub Copilot and ChatGPT on error rates of developed code by students

Within the scope of this research objective, the results of the following questions asked to students after the experiment phase are presented in the figure 7 and 8.

- How often did AI-generated code lead to errors? 1. Rarely 2. Occasionally 3. Frequently
- Were the AI tools effective in helping you solve problems and fix errors? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Linear-by-Linear Association test because of comparison of the frequency of produced errors using AI Tools like GitHub Copilot and ChatGPT.

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
How often did AI-generated code lead to errors?	Rarely	9	31	40
	Occasionally	14	30	44
	Frequently	12	11	23
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.869[a]	2	.053
Linear-by-Linear Association	5.470	1	.019
N of Valid Cases	107		

Figure 7 How often did AI-generated code led to errors

Based on results in figure 7, we conclude that number of students responses positively about AI generated code with errors rarely is smaller comparing the number of students responses positively about AI—generated code led to errors in occasionally and frequently cases. Additionally, the relationship between AI Tools and error frequency is not statistically significant considering the Chi-Square result because p is greater than 0.05 (p = 0.053). While, based on the Linear-by-Linear Association (p = 0.019) result, ChatGPT lead to more stable code with fewer frequent issues compared to GitHub Copilot because it shows a significant trend where the students of one AI Tool (ChatGPT) consistently experienced fewer frequent errors compared to GitHub Copilot.

Also, in the following are the collected data (categorical data) which are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of AI Tools effectiveness in helping students to solve problems and fixed errors using GitHub Copilot or ChatGPT.

Based on results in figure 8, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in AI tools effective in helping them to solve problems and fix errors because the p-values in both cases are greater than 0.05. According to students' responses, neither AI Tools did not pass each of one in terms of solve problems and fix errors.

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	
Were the AI tools effective in helping you solve problems and fix errors?	Yes	25	61	86
	No	10	11	21
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.638[a]	1	.104		
Fisher's Exact Test				.124	.088
N of Valid Cases	107				

Figure 8 Were the AI tools effective in helping you solve problems and fix errors

If we compare the above results in figure 8 (after experiment) with the following results in figure 9 (before experiments), it is obviously clear that

students also before experiments were not confident at their skills problem-solving in web application development. So, the usage of AI Tools does not

change the problem-solving skills because there is no statistically significant difference in results. Here is the following question asked to students before the experiment phase:

- Do you feel confident in your problem-solving skills in web application development? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of confidence in problem-solving skills of students of two groups which used AI Tools like GitHub Copilot and ChatGPT.

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Do you feel confident in your problem-solving skills in web application development?	Yes	15	35	50
	No	22	36	58
Total		37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.750ᵃ	1	.386		
Fisher's Exact Test				.422	.254
N of Valid Cases	108				

Figure 9 Do you feel confident in your problem-solving skills in web application development

Based on results in figure 9, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in confidence at problem-solving skills because the p-values in both cases are greater than 0.05 (0.386, 0.422 and 0.254).

4.2.4. Gathering the qualitative feedback of students who experienced the usage of GitHub Copilot and ChatGPT during the development process

In the context of this research objective, the results from the two following questions asked to students after the experiment phase are presented in the figure 10.

- Would you rate your overall experience with AI tools as excellent? 1. Yes 2. No
- Would you rate your overall experience with AI tools as poor? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of experience of two groups of students using AI Tools like GitHub Copilot and ChatGPT during the development process.

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Would you rate your overall experience with AI tools as excellent?	Yes	17	53	70
	No	18	19	37
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.527[a]	1	.011		
Fisher's Exact Test				.017	.010
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	
Would you rate your overall experience with AI tools as poor?	Yes	10	14	24
	No	25	58	83
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.128[a]	1	.288		
Fisher's Exact Test				.328	.206
N of Valid Cases	107				

Figure 10 *Experience of students about the usage of GitHub Copilot and ChatGPT during the development process*

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
What are your expectations from 1/ 2 in assisting with web-application development?	Code Generation	11	11	22
	Ease and Efficiency	7	11	18
	Beginner Supports	11	16	27
	Professional Development	8	32	40
	Ease and Efficiency & Professional Development	0	1	1
Total		37	71	108

Figure 11 *Students' expectations from 1. GitHub Copilot/ 2. ChatGPT in assisting with web-application development*

Based on results in figure 10, we conclude that there is statistically significant difference between students who selected GitHub Copilot or ChatGPT in "excellent" experience because the p-values in both cases are less than 0.05 (0.011, 0.017 and 0.010). While, for the "poor" experience there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT because the p-values in both cases are greater than 0.05 (0.288 0.328 and 0.206).

Also, the students are asked before the experiment phase about the following question:

- What are your expectations from 1. GitHub Copilot/ 2. ChatGPT in assisting with web-application development? 1. Code Generation, 2. Ease and Efficiency, 3. Beginner Supports, 4. Professional Development, 2. Ease and Efficiency & 4. Professional Development.

Based on students' exaptation of assisting by AI Tools in web application developed, ChatGPT will assist more in professional development than GitHub Copilot while the expect that in code generation will be the same. The details of answered question are in the following figure 11 of descriptive statistics.

4.2.5. Identifying the different student's perspective on how GitHub Copilot and ChatGPT supports their learning and development

For this research objective, the results from the following questions asked to students after the experiment phase are presented in the figure 12 and figure 13.

- Which tool was more helpful for learning and development: GitHub Copilot or ChatGPT? Why? 1. GitHub Copilot, 2. ChatGPT, 3. None of the Above.
- Did the use of AI tools enhance your understanding of coding concepts? 1. Yes 2. No
- Did the AI tools make it harder to identify and resolve complex issues? 1. Yes 2. No

The collected data (categorical data) about helpful of AI Tools for learning and development are analyzed in SPSS through Chi-Square test because of comparison of two groups of students using AI Tools like GitHub Copilot and ChatGPT. These results are shown in the following 12:

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Which tool was more helpful for learning and development: GitHub Copilot or ChatGPT?	GitHub Copilot	9	0	9
	ChatGPT	22	68	90
	None of the Above	2	4	6
	Both of them	2	0	2
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.423[a]	3	.000
N of Valid Cases	107		

Figure 12 Which of tools was more helpful for learning and development

Based on students' responses, ChatGPT was more helpful for learning and development than GitHub Copilot. This is shown also through result of p, which is less than 0.05, it shows the significant association between categorical data. While the collected data (categorical data) about understanding of coding concepts by students and identification and resolving complex issue by students using AI Tools are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of two groups of students using AI Tools like GitHub Copilot and ChatGPT. These results are shown in the following figure 13:

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Did the use of AI tools enhance your understanding of coding concepts?	Yes	22	57	79
	No	13	15	28
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.243[a]	1	.072		
Fisher's Exact Test				.100	.060
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Did the AI tools make it harder to identify and resolve complex issues?	Yes	10	18	28
	No	25	54	79
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.155[a]	1	.693		
Fisher's Exact Test				.815	.432
N of Valid Cases	107				

***Figure 13** Understanding of coding concepts by students and identification and resolving complex issue by students using AI Tools*

Based on results in figure 13, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in understanding of coding concepts because the p-values in both cases are greater than 0.05 (0.072, 0.100 and 0.060).

Also, there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in their usage of AI Tools for identifying and resolving complex issues because the p-values in both cases are greater than 0.05 (0.693, 0.815 and 0.432).

If we analyze the students' responses before the experiment regarding their approach about solving complex coding problem, students of second year have different responses from students of third year, this is shown in the following categorical data responses for the following question:

▪ How do you currently approach solving a complex coding problem?

Response of students of *second year*

1. Using ChatGPT or AI Tools as the Primary Problem-Solving Tool

2. Combining AI with Other Resources like Google, Forums, or YouTube

3. Systematic Approach or Self-Solving (with AI as a Secondary Tool)

4. Emotional Approach or Without a Defined Method

Response of students of *third year*

11. Initial Problem Understanding and Analysis

33. Step-by-Step Problem Decomposition and Solution Approach

22. Use of AI Tools and External Resources

44. Reflection and Review

In the following 14 are shown details of answered question through descriptive statistics:

| | | Which AI Tool would you want to select in this experiment? | | |
		GitHub Copilot	ChatGPT	Total
How do you currently approach solving a complex coding problem?	Using ChatGPT or AI Tools as the Primary Problem-Solving Tool	8	26	34
	Combining AI with Other Resources like Google, Forums, or YouTube	7	6	13
	Systematic Approach or Self-Solving (with AI as a Secondary Tool)	5	5	10
	Emotional Approach or Without a Defined Method	5	3	8
	Initial Problem Understanding and Analysis	1	9	10
	Use of AI Tools and External Resources	8	14	22
	Step-by-Step Problem Decomposition and Solution Approach	1	5	6
	Reflection and Review	2	3	5
Total		37	71	108

Figure 14 Students' approach solving a complex coding problem

.

| | | Which AI Tool would you want to select in this experiment? | | |
		GitHub Copilot	ChatGPT	Total
Do you believe AI tools will enhance your coding efficiency and learning? Why or why not?	Yes, AI increases efficiency and learning	27	61	88
	Yes, AI is efficient, but it has some limitations	7	5	12
	No, AI does not help much with learning	2	3	5
	Yes, AI is efficient and enhances learning, but it does not replace the professor	1	2	3
Total		37	71	108

Figure 15 Students believes that AI tools will enhance coding efficiency and learning

Also, the students' responses before the experiment regarding their believes that AI tools will enhance coding efficiency and learning are shown in the following descriptive statistics of figure 15Based on results in figure 15, we conclude that students believes that ChatGPT increases efficiency and learning more than GitHub Copilot.

Within the scope of this research objective, we analyze the students' responses after the experiment regarding the impact of GitHub Copilot and ChatGPT on problem solving abilities of students. In the following are shown the results of responses based on categorical data:

4.2.6. Exploring the impact of GitHub Copilot and ChatGPT on problem solving abilities of students

| | | Which AI Tool would you want to select in this experiment? | | |
		GitHub Copilot	ChatGPT	Total
How did AI tools impact your approach to problem-solving?	Positive Impact	11	53	64
	Partial Positiv Impact	16	9	25
	Negativ Impact	5	9	14
	Critical Thinking and Increased Questioning	3	1	4
Total		35	72	107

Figure 16 The impact of GitHub Copilot and ChatGPT on problem solving abilities of students

Based on results in figure 16, we conclude that ChatGPT have more positive impact in students' approach about problem-solving than GitHub Copilot. While GitHub Copilot is more about critical thinking and increasing questions during problem solving.

Also, the collected data (categorical data) about AI Tools on making easier to identify and resolve complex issues by students using AI Tools are

analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of two groups of students using AI Tools like GitHub Copilot and ChatGPT. These results are shown in the following figure 17:

| | | Which AI Tool would you want to select in this experiment? | | |
		GitHub Copilot	ChatGPT	Total
Did the tools make it easier to identify and resolve complex issues?	Yes	28	64	92
	No	7	8	15
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.544[a]	1	.214		
Fisher's Exact Test				.243	.171
N of Valid Cases	107				

Figure 17 AI Tools on making easier to identify and resolve complex issues by students

Based on results in figure 17, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in making easier to identify and resolve complex issues by students because the p-values in both cases are greater than 0.05 (0.214, 0.243 and 0.171). Moreover, we analyze the students' responses before the experiment regarding the students' confidence in web application development troubleshooting skills.

In the following are shown the results of responses based on categorical data:

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Do you feel confident in your web application development troubleshooting skills?	Yes	18	29	47
	No	19	42	61
Total		37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.603[a]	1	.438		
Fisher's Exact Test				.540	.283
N of Valid Cases	108				

Figure 18 The impact of GitHub Copilot and ChatGPT on students 'approach to problem solving

Based on results in figure 18, we conclude that there is no statistically significant difference between students who selected GitHub Copilot or ChatGPT in their confidence in web application development troubleshooting skills because the p-values in both cases are greater than 0.05 (0.438, 0.540 and 0.283).

4.2.7. Exploring the impact of GitHub Copilot and ChatGPT on soft skills like as critical thinking, collaboration, and adaptability

For this research objective, the results from the following questions asked to students after the experiment phase:

- Did the use of AI tools improve your collaboration with peers?   1. Yes 2. No
- Did AI tools affect your suitability during the development process? 1. Yes 2. No
- Did AI tools encourage your critical thinking? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of two groups of students using AI Tools like GitHub Copilot and ChatGPT. These results are shown in the following figure 19: Based on results in figure 19, we conclude that in improving collaboration with peers the GitHub Copilot showed a statistically significant advantage over the ChatGPT because the p-values in both cases are less than 0.05 (0.023, 0.030 and 0.026). However, for the other questions no statistically significant differences were observed between the two AI tools. If we compare the above results in figure 19 (after experiment) with the following results in figure 20 (before experiments), it is obviously clear that students before experiments were not in collaboration with their peers. Thus, the usage of AI Tools does change the collaboration with the peers because before experiments there is no statistically significant difference in results while after experiments has the statistically significant difference. Here are the following questions asked to students before the experiment phase:

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	Total
Did the use of AI tools improve your collaboration with peers?	Yes	25	64	89
	No	10	8	18
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.131[a]	1	.023		
Fisher's Exact Test				.030	.026
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	Total
Did AI tools affect your suitability during the development process?	Yes	31	65	96
	No	4	7	11
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.074[a]	1	.785		
Fisher's Exact Test				.747	.513
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	Total
Did AI tools encourage your critical thinking?	Yes	24	60	84
	No	11	12	23
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.041ᵃ	1	.081		
Fisher's Exact Test				.131	.070
N of Valid Cases	107				

Figure 19 *The impact of GitHub Copilot and ChatGPT on soft skills like as critical thinking, collaboration, and adaptability- after experiment*

- Are you comfortable collaborating with colleagues on coding projects? 1. Yes 2. No
- Are you adaptable to changes in project requirements or technology during development? 1. Yes 2. No
- Do you think you have critical thinking skills when faced with coding challenges? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Chi-Square and Fisher Exact test because of comparison of two groups of students using AI Tools like GitHub Copilot and ChatGPT. These results are shown in the following figure 20:

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Are you comfortable collaborating with colleagues on coding projects?	Yes	36	70	106
	No	1	1	2
Total		37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.224ᵃ	1	.636		
Fisher's Exact Test				1.000	.570
N of Valid Cases	108				

		Which AI Tool would you want to select in this experiment?		
		GitHub Copilot	ChatGPT	Total
Are you adaptable to changes in project requirements or technology during development?	Yes	26	51	77
	No	11	20	31
Total		37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.029ᵃ	1	.865		
Fisher's Exact Test				1.000	.517
N of Valid Cases	108				

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	
Do you think you have critical thinking skills when faced with coding challenges?	Yes	28	59	87
	No	9	12	21
Total		37	71	108

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.856ᵃ	1	.355		
Fisher's Exact Test				.443	.249
N of Valid Cases	108				

Figure 20 The impact of GitHub Copilot and ChatGPT on soft skills like as critical thinking, collaboration, and adaptability- before experiment

Based on results in figure 20, all questions have no statistically significant differences were observed between the two AI tools.

4.2.8. Providing recommendations for usage of GitHub Copilot and ChatGPT in educational settings based on this study

In the context of this research objective, the results from the two following questions asked to students after the experiment phase are presented in the figure 21.

- Based on your experience, would you recommend integrating AI tools like GitHub Copilot and ChatGPT into educational settings? 1. Yes 2. No
- Based on your experience, is there still a need for a professor for application development in educational institutions even after the integration of AI Tools? 1. Yes 2. No

The collected data (categorical data) are analyzed in SPSS through Independent Sample test because of comparison of experience of two groups of students using AI Tools like GitHub Copilot and ChatGPT during the development process. Based on results in figure 21, all questions have no statistically significant differences were observed between the two AI tools. Also, before experiment we analyze the students' responses regarding their concerns about using AI tools in web development. In the following are shown the results of responses based on categorical data.Based on results in figure 22, we conclude that most of students that preferer to use ChatGPT have no concern about using AI Tools in web development. Even if, some students have concern about technical limitation and experience. Moreover, students are asked about their recommendations for improving the use of the AI tools in learning environments. Based on qualitative data which are categorized and summarized the students recommend:

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	
Based on your experience, would you recommend integrating AI tools like GitHub Copilot and ChatGPT into educational settings?	Yes	29	64	93
	No	6	8	14
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.753[a]	1	.385		
Fisher's Exact Test				.379	.281
N of Valid Cases	107				

		Which AI Tool would you want to select in this experiment?		Total
		GitHub Copilot	ChatGPT	
Based on your experience, is there still a need for a professor for application development in educational institutions even after the integration of AI Tools?	Yes	33	64	97
	No	2	8	10
Total		35	72	107

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.810[a]	1	.368		
Fisher's Exact Test				.493	.303
N of Valid Cases	107				

Figure 21 *Recommendations for usage of GitHub Copilot and ChatGPT in educational settings based on this study*

| | | Which AI Tool would you want to select in this experiment? | | |
		GitHub Copilot	ChatGPT	Total
Do you have any concerns about using AI tools in web development? If so, what are they?	No Concerns	20	41	61
	Technical Limitations	3	14	17
	Dependency Concerns	8	6	14
	Experience Concerns	6	10	16
Total		37	71	108

Figure 22 Students' concerns before experiments about using AI tools in web development

Integration of AI Tools into the Learning Environment, the students recommend incorporating AI Tools in classroom as supplementary resource but not to replace professors. While, for an effective learning they recommend collaborating students, professors and AI tools. Also, their recommendations are about introducing AI Tools into curricula be Institution but with proper training for students and professors because based on students' responses AI Tools enhance problem solving in real time and allow to access resources during the learning process. Moreover, AI Tools need to support teamworking and group discussions withing learning environment.

Guidance from Educators during usage of AI Tools to ensure that these tools not to replace human instruction just to be as complementary. Also, they should support learning process does not dominate it on logical understanding and critical thinking. Based on students' responses the professors should guide students how to interact with AI tools in terms of framing and clear articulation of queries or requests but not to use AI Tools for outsourcing entire courses' projects.

Skill Development and Practice, the students recommend having prior knowledge, skills and practice on coding to use AI Tools effectively and maximize tools' benefits.

Accessibility and Usage Policies, based on students' responses the institutions should govern the extend and condition on usage of AI Tools in moderate level to ensure the ethical and balanced application during the learning process but not to shortcut it.

Through the findings in this study are revealed the advantages and limitations of GitHub Copilot and ChatGPT during the web development application by students.

3.2. Discussion

This study enhances the knowledge through the interpretation and analysis of the findings related to the students' preferences for AI Tools and research objectives in the context of existing research and potential for future research.

According to the results in Figure 2, most of the students have chosen the ChatGPT tool for web application development tasks. Although, we expected that half of students will choose ChatGPT and half of them GitHub Copilot, but their motivation was strongly related to the familiarity with the AI Tool, and they have less technical difficulties with activation and usage compared to GitHub Copilot. While the students that choose the GitHub Copilot were motivated by their interest in trying a new AI Tool.

The author Strzelecki, A. (2024) recommended for future studies to explore the usage of ChatGPT by students of higher education [13]. Thus, our study already addresses this issue by examining preferences of students for AI Tools like ChatGPT and GitHub Copilot for web application development tasks, but our studies is more advanced than recommendation because it contained experiments except the pre and post surveys about exploring usage.

The authors Hou, Irene at al. (2024) also treated the usage of ChatGPT by computing students but comparing with our study their number of students that participated in their study were smaller, 47 students in survey and 8 students in interview [14]. Also, the author Jo Hyeon (2024) treated the usage of ChatGPT by students and suggested to clear the benefits of AI tools in order it could increase the usage of them in educational settings. In this context our study treated this suggestion of benefits clarification through 8 research objectives [15]. Moreover, the author Popovici, Matei-Dan. (2023) treated the usage of ChatGPT by students

and based on his study students were using this AI Tool before 6 months since he started the study [17].

In contrast to the above authors that treated only usage of ChatGPT, Peslak, Alan, and Lisa Kovalchick (2024) treated the usage of ChatGPT and GitHub Copilot by programmers. Based on their results the ChatGPT is more used than GitHub Copilot [16]. In their respondent's group 'learning to code' students also participated. Also, the authors Kapakos, William A., and H. Kevin Fulk. (2024) treated the usage of GitHub Copilot by business students in an information system course. Based on this study students have in general positive perception about ease of use of GitHub Copilot and this AI Tool has potential to be of benefit in educational settings [18]. While the authors Zhang, Beiqi et al. (2023) suggested for future studies to explore when and by whom to use GitHub Copilot, thus our study treated this issue by using it by our students with and without experience in web development during the experiment [19].In the following subsection are shown the interpretation and analysis of the findings related to our research objectives.

3.2.1. Comparison of GitHub Copilot and ChatGPT on task completion time by students

Based on our study results the average of task completion time for ChatGPT is less than for GitHub Copilot for 7.99 minutes, but this difference is not statistically significant. The task completion depends more on factors like familiarity of students with AI Tools and task complexity, for that reason in future studies our focus should be on improving the students' AI tools proficiency. The authors Jošt, Gregor et al. (2024) support our study in the context that familiarity impacts the task completion [20]. Also, the authors Vaithilingam et al. (2022) highlight in their study that GitHub Copilot may not reduce the task completion time if not used properly. While, the authors Noy, Shakked, and Whitney Zhang (2023) in their experiment founded that ChatGPT reduce the task completion time which is in line with our study [24].However, the authors Denny et al. (2023) and Wermelinger Michel (2023) strongly recommended the GitHub Copilot for programing tasks, thus, this also support our study because our students used it in web development tasks [22, 23].

3.2.2. Assessing and comparing of GitHub Copilot and ChatGPT on the quality of code produced by students

According to study results, there is no statistically significant difference between AI tools like ChatGPT and GitHub Copilot in the quality of code generated through experiments performed by students. Thus, the findings suggest equivalence between AI Tools in supporting students in various coding tasks especially related to their confidence in writing new code, code quality, modifying, debugging or optimizing existing code. Based on related research, Yetiştiren et al. (2023) compared GitHub Copilot, Amazon CodeWhisperer, and ChatGPT in terms of quality of code and their findings show that ChatGPT had the higher success through evaluation comparing with the two other AI Tools [25]. While the authors Beer et al. (2024) in their study conclude that both ChatGPT and GitHub Copilot have excellent code quality, this study supports our study about equivalence between these two AI Tools [26].

3.2.3. Evaluating and comparing GitHub Copilot and ChatGPT on error rates of developed code by students

Findings related to these research objectives showed that ChatGPT led to more stable code with fewer frequent issues compared to GitHub Copilot based on Linear-by-Linear Association test. Whereas, in problem-solving and student confidence there is no significant difference between ChatGPT and GitHub Copilot. Based on this, each AI Tool can be integrated in educational settings to assist students depending on their needs. The AI Tools reduce errors is shown also in study results of author Georgsen Roar Elias (2023) [27]. Also, the authors Solohubov et al. (2023) support our findings that through AI Tools the errors in code are less because they eliminate the human factors that impact on adding error through code writing [28].

3.2.4. Gathering the qualitative feedback of students who experienced the usage of GitHub Copilot and ChatGPT during the development process

Based on findings of this research objective, the treated AI tools in this study have their strengths, but ChatGPT is preferred more for enhancement of the learning experience and support of professional development. Thus, ChatGPT is considered valuable in web application development task in education. Moreover, GitHub Copilot is more important for intermediate and advanced tasks while for code generation ChatGPT and GitHub Copilot are equally effective. Based on research conducted, several research papers present their result of ChatGPT usage experience in educational

settings [13, 14, 15, 17], while usage of GitHub Copilot experience is rare [19].

3.2.5. Identifying the different student's perspective on how GitHub Copilot and ChatGPT supports their learning and development

Findings about this research objective suggest both AI Tools for conceptual understanding and problem-solving because their support is equivalent while, ChatGPT is highlighted as a clear preference of students because it is more supportive for general learning and development based on students' perception. Based on research conducted, several research papers present their result of ChatGPT as a supportive tool for students' learning and development [13, 14, 15, 17]. Considering these findings, Faculty should continue guiding students but with complementary AI tools.

3.2.6. Exploring the impact of GitHub Copilot and ChatGPT on problem solving abilities of students

Based on our findings, ChatGPT is more flexible and focused on solution strategies for problem solving, while GitHub Copilot supports deeper critical thinking. Despite this, both AI Tools are comparable in offering the assistance for solving complex problems without significantly affecting the confidence and troubleshooting skills.

Compared to our study, the author Wermelinger (2023) highlighted that GitHub Copilot can be frustrating for problem-solving and tasks development because of appearing errors and students in those cases require solid understanding of the semantics of language to modify code for problem solving [29, 30]. While the author Biswas (2023) agrees with our findings, who has emphasized that ChatGPT assists students in a variety of tasks related to development (programming) including error fixing [29, 31].

3.2.7. Exploring the impact of GitHub Copilot and ChatGPT on soft skills like as critical thinking, collaboration, and adaptability

According to our findings, GitHub Copilot has more impact on students' collaboration than ChatGPT, while adaptability and critical thinking to students is supported from both AI Tools in equal ways. Considering these findings, both AI Tools can be integrated in educational settings for soft skills but if the learning outcomes of the courses are more specific for encouraging the students' collaboration than should consider GitHub Copilot,

also it should be considered more for critical thinking. Cagáňová, Dagmar, and Natália Horňaková (2024) also treated the soft skills because they highlighted that as new skills and competencies in the era of digitalization based on the European Union settings. The authors consider soft skills as crucial skills in employees 'selection because artificial intelligence or technology cannot replace soft skills. We agree with these authors for replacement, but AI Tools based on our findings can impact improvement of soft skills. Also, the authors Dolev, Niva, and Yariv Itzkovich (2020) agree that soft skills evolve the work environment and in the digital era the soft skills are new hard skills that helps to cooperate in work to adapt to continuous change and to think critically.

3.2.8. Providing recommendations for usage of GitHub Copilot and ChatGPT in educational settings based on this study

According to our study's findings the AI Tools have significant potential in educational settings with the role of supportive not central. Through students' feedback analysis it is understood that the role of professor is vital for deep learning, guiding students and expanding the way of thinking critically to navigate and interact with these AI Tools for web development tasks. Institutions should incorporate the AI Tools in a balanced way into their curricula by providing training, enhancing learning and ensuring always the ethical use of them. Also, based on students' feedback there is a strong consensus between students for AI Tools benefits in learning support. Based on related research with our findings, most of the studies highlighted the potential of AI Tools in a supportive role not as a central tool for students in educational settings [34, 35, 36, 37, 38].

4. Conclusion

This study will contribute through the recommendations of usage of AI tools in educational settings by providing the detail comparison of GitHub Copilot and ChatGPT based on experiential study and pre-post survey results and discussions.

These recommendations will allow educators and students to make an informed decision about integration of AI tools in their learning process in the computer sciences courses related to web development application with the intention to shape the educational practices and improve students by enhancing coding, problem solving skills, and soft skills like collaboration, critical thinking and adaptability.

The recommendations of this study aim to improve educational experience through educators and ensuring that students will gain technical and soft skills to prepare students for future challenges in the technology sector. Moreover, the aims of these recommendations are that educational institution to contribute in development of skilled and adaptable workforce in the field of web application development.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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