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Investigating the Mathematical Performance of Undergraduate Students in the Flipped Learning Method Grouped by the DISC Personality Test Along with the Lecturer's Scaffolding

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A B S T R A C T

Objective: This study aims to leverage psychological aspects within the Flipped Learning method by presenting a novel technique and examining the mathematical performance of undergraduate students.

Methods and Materials: This descriptive-analytical study was conducted in the 2022-2023 academic year with 89 undergraduate students from the Computer Science field at the Islamic Azad University, Science and Research Branch. Students were divided into three General Mathematics II classes and grouped based on the DISC Personality Test. A sample size of 75 was selected using stratified random sampling. The Flipped Learning method involved ten 120-minute sessions, with instructional scaffolding provided through the iGap Iranian application. Pretest and posttest scores, along with various performance metrics, were analyzed using SPSS version 27. Statistical tests, including Paired-Samples T-Test and Independent-Samples T-Test, were conducted to evaluate the hypotheses.

Findings: The results indicated significant improvement in students' mathematical performance post-intervention, confirming the positive effect of the Flipped Learning method. No significant differences were found between female and male students' academic progress, suggesting equal benefits across genders. Extroverted students showed greater academic progress than introverted students, with extroverted females and males outperforming their introverted counterparts. Lecturer scaffolding significantly enhanced students' Mathematical Mind Processing (MMP), with introverted students showing more substantial MMP improvements compared to extroverts. No significant differences were found in companionship between introverts and extroverts or between female and male students.

Conclusion: The study concludes that the Flipped Learning method, when combined with the DISC Personality Test and lecturer scaffolding, significantly

enhances undergraduate students' mathematical performance. This approach benefits both genders equally and supports greater academic progress for extroverted students. Scaffolding plays a crucial role in improving cognitive processing, particularly for introverted students. These findings highlight the importance of personalized and interactive teaching methodologies in higher education.

Keywords: *Academic performance, Creative grouping, Gender, Introvert student, Extrovert student*

1. Introduction

The investigation of human needs has long been a focal point in the fields of psychology and sociology. Interactions among individuals are essential for meeting these needs (Glasser, 1999). According to Maslow's Motivational Theory, if educators possess adequate awareness and understanding of physiological, security, and emotional needs, as well as the need for respect, creativity, innovation, and perfection, the learning process can be significantly enhanced. Alderfer's Theory suggests that to boost student performance, educators must address higher-level needs and encourage active participation in class activities (Schultz & Schultz, 2020).

The educational system, which receives a substantial portion of the government's annual budget, is crucial for the social, political, cultural, and economic development of society. Effective teaching techniques are vital for maintaining a high-quality educational system (Karimi, 2021). Geach (1978) defines teaching as an activity conducted by one person to facilitate the learning process of another (Banaizada, 2022). Learning is described as a relatively stable change in attitudes, behavior, and performance. However, teaching and learning are distinct processes, and not all teaching methods result in effective learning (Alibeigloo et al., 2021).

Given the varying learning speeds and levels among students and advancements in information technology, educators must adopt appropriate teaching methods (Al-Rawi, 2013). Recent decades have seen the emergence of innovative teaching techniques that are more effective and efficient than traditional methods, based on findings from psychology and educational sciences (Alibeigloo et al., 2021).

The Flipped Learning method reverses the traditional order of teaching and homework. Students review course materials at home in various formats, while classroom time is devoted to practice, questions, discussions, and other activities (Kartali et al., 2020). This method involves grouping students to facilitate productive interactions, using various strategies such as homogeneous, heterogeneous, voluntary, random, or ability-based grouping.

Instructional scaffolding is an active process that supports learners in performing specific activities, utilizing human resources such as instructors, peers, or experts, as well as digital devices. Scaffolding enhances emotional engagement (Acosta-Gonzaga & Ramirez-Arellano, 2022). Educational support in scaffolding environments increases students' co-regulation and self-regulation learning skills (Dian Martha et al., 2023).

Dr. Eric Mazur, known for peer education, and other educators pursued active teaching methods for student-centered learning in the late 1990s. Dr. Baker developed an instructional strategy that emphasized class time for mastering knowledge and assigned lecture content as homework. This approach, combined with the introduction of computers and the Internet in the 1980s and 1990s, transformed educational practices. By the mid-2000s, high school chemistry teachers Aaron Sams and Jonathan Bergman popularized the Flipped Learning model by uploading lectures to YouTube for students to watch before class, sparking widespread academic interest (Gopalan et al., 2022).

Mousapour (2014) suggests that no single instructional technique is universally superior, regardless of circumstances, objectives, audience, and cost. Several variables must be considered when selecting an instructional approach, including training objectives, topics, time, audience, level, scenario, and infrastructure. Educators need critical and integrated thinking, risk-taking, sensitivity, knowledge, practical experience, and self-mastery to choose the best method (Mousapour, 2014).

Effective teaching strategies challenge learners and raise educational standards, but they also come with challenges and requirements (Shiranibidabadi et al., 2016). Student satisfaction is a key criterion for evaluating teaching quality, particularly when active instructional approaches are used (Thi Mai Huong, 2022).

A meta-analysis by Lo et al. (2017) showed that the Flipped Learning method benefits student learning in three primary ways: increased classroom time for practice,

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integration of new information with existing beliefs, and immediate feedback. However, challenges include students' unfamiliarity with the method and the significant initial effort required from educators (Lo et al., 2017).

Sopamena et al. (2023) found that the Flipped Learning method has a moderate effect on student learning speed in university mathematics compared to traditional approaches, suggesting its potential for improving academic quality (Sopamena et al., 2023). Research by Rizos, Kolokotronis, and Papanikolaou (2023) indicated improvements in student participation, attitudes towards learning, control over learning pace, time management, and group work performance, despite challenges like regular participation, handling assignments, and managing the process (Rizos et al., 2023).

The Flipped Teaching approach enhances student learning and academic progress in high school mathematics, although some studies did not show academic progress, indicating that subject matter and instructional approach play significant roles (Ghanaat & Habibzadeh, 2020). According to Fernández-Martín, Romero-Rodríguez, Gómez-García, and Navas-Parejo (2020), the Flipped Learning method generally improves students' knowledge and attitudes toward mathematics, benefiting teamwork, self-regulation, autonomy, and academic performance (Fernández-Martín et al., 2020).

Students typically prefer the Flipped Learning method over conventional approaches due to positive reactions, engaging discussions, motivation, better subject understanding, and a desire for class participation (Pardimin et al., 2022). Alipour and Alipour (2022) found that the Flipped Learning method enhances learning efficiency, personalization, and technological proficiency (Alipour & Alipour, 2022).

The Flipped Learning method benefits low-performing students by improving learning effectiveness, reducing cognitive load, increasing engagement, and enhancing attitudes, motivation, satisfaction, and self-efficacy (Sarker, 2023). However, student adaptation to this method and the increased workload for educators are significant obstacles (Toofaninejad et al., 2019).

Group work in Flipped Classrooms significantly boosts academic progress compared to traditional structures (Jakobsen & Knetemann, 2017). This method makes learning more accessible and involves students in practical teamwork, fostering healthy competition and broadening their perspectives (Johnson, 2020).

Salazar (2016) observed significant score improvements using two grouping methods in a Flipped Learning study, with Salazar's innovative grouping method showing notable results. Hastuti (2020) found that the Flipped Learning method positively impacts students' enjoyment of mathematics (Hastuti, 2020).

To maximize mathematical learning, continuous focus on optimal grouping methods based on educational environments is crucial (Oh, 2020). Innovative grouping techniques in the Flipped Learning method can significantly impact students' mathematical performance. This study, the first of its kind, used the DISC Personality Test for grouping students and analyzed their mathematical performance. Preliminary findings suggest that addressing psychological aspects and monitoring activities closely are essential for maximizing the benefits of the Flipped Learning method with lecturer scaffolding.

2. Methods and Materials

2.1. Study Design and Participants

This descriptive-analytical study was conducted during the 2022-2023 academic year to investigate the mathematical performance of undergraduate students. The study was designed to employ the Flipped Learning method, integrating the DISC Personality Test for grouping students and providing lecturer scaffolding to enhance learning outcomes. The participants consisted of 89 undergraduate students enrolled in the Computer Science program at the Islamic Azad University, Science and Research Branch. These students were divided into three General Mathematics II classes, labeled Class 1, Class 2, and Class 3, with 44, 20, and 25 students, respectively. A sample size of 75 students was determined using Morgan's Table and selected through stratified random sampling to ensure representativeness.

2.2. Measures

The DISC Personality Test was administered to group students based on their personality traits into four categories: Dominance (D), Influence (I), Steadiness (S), and Conscientiousness (C). Each student completed the test at the beginning of the course, and results were used to form balanced groups that included a mix of personalities. The DISC Personality Test is a well-validated tool with high reliability (Cronbach's alpha ranging from 0.70 to 0.85) and confirmed validity in multiple studies (Schultz & Schultz, 2020).

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To evaluate mathematical performance, a pretest was conducted at the beginning of the course, covering prerequisite content from General Mathematics I, including topics such as Limits, Continuity, Integration by Parts, and Integration of Trigonometric Functions. The same topics were revisited in a posttest at the end of the intervention to measure improvements in mathematical understanding and performance. The tests were scored on a scale of 0 to 100, with reliability confirmed through pilot testing (Cronbach's alpha = 0.82).

A virtual group for each class was created on the iGap Iranian application. This platform facilitated student-student and lecturer-student interactions outside the classroom. Interactions were monitored and recorded to assess engagement and participation. The reliability of interaction data was ensured through consistent monitoring protocols.

Classroom performance was assessed using Class Starred Exercises (CSE) and Class Exercises (CE). CSEs were complex problems requiring students to apply knowledge from the session, scored on a scale of 0 to 10. CEs were scaffolded exercises that bridged the gap between basic concepts and complex applications, scored on a scale of 0 to 20. The reliability of these assessments was validated through consistent grading rubrics (inter-rater reliability = 0.88).

MMP was evaluated by comparing student performance before and after scaffolding. Scores from CSEs were used to calculate MMP Before Scaffolding (MMPB) and MMP After Scaffolding (MMPA). Each MMP score was recorded on a scale of 0 to 20. The reliability of MMP scoring was confirmed through repeated measures (test-retest reliability = 0.85).

The Companionship score assessed students' engagement in class discussions, follow-up on exercises, and overall enthusiasm. This score was recorded during each session to evaluate students' collaborative behaviors, scored on a scale of 0 to 20. The reliability of the companionship assessment was confirmed through peer and self-reports (Cronbach's alpha = 0.80).

2.3. Intervention

The Flipped Learning method was implemented across ten 120-minute sessions. Students were provided with PDF materials and 30-minute instructional videos uploaded to the lecturer's Aparat channel before each class. These materials covered essential definitions, issues, and elementary-level examples. Students were expected to study these materials and prepare questions for classroom discussions. Group formation was based on the DISC Personality Test results, with each group ideally comprising one student from each personality category. These groups engaged in both intra-group and intra-class activities to enhance learning through peer interactions and collaborative problem-solving.

Lecturer scaffolding was provided through additional exercises (Class Exercises, CE) designed to support learning between basic content and complex problems (Class Starred Exercises, CSE). The lecturer monitored and guided student progress using coordinates assigned to each student, ensuring individualized feedback and support. The iGap platform was used for continuous interaction and support outside classroom hours. Students were encouraged to discuss course materials, share insights, and seek help through this platform, promoting continuous learning. To further facilitate the learning process, the lecturer offered timely feedback and created a dynamic and interactive classroom environment that encouraged active participation and engagement from all students.

2.4. Data analysis

Data analysis was conducted using SPSS version 27. Descriptive statistics, including means and standard deviations, were calculated for pretest and posttest scores, as well as for performance metrics across different groups. The Run-Test was conducted to confirm the randomness of the sample selection from the three classes. The Kolmogorov-Smirnov Test was used to assess the normality of the data distribution for both pretest and posttest scores. A Paired-Samples T-Test was utilized to compare pretest and posttest scores, determining the effect of the Flipped Learning method on mathematical performance. Independent-Samples T-Tests were conducted to compare educational improvements between different groups (e.g., gender, introverts vs. extroverts) and to evaluate the impact of personality traits on learning outcomes. Cohen's d was calculated to measure the effect size of the intervention on various performance metrics, providing a standardized measure of the impact. For data that did not meet the assumptions of normality, the Mann-Whitney U Test was used to compare groups, such as introverts vs. extroverts and female vs. male students, in terms of their companionship scores. This comprehensive analysis ensured a thorough evaluation of the research hypotheses and provided robust insights into the effectiveness of the Flipped Learning

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method combined with the DISC Personality Test and lecturer scaffolding.

3. Findings and Results

The significance levels of the Run-Test in the three classes (Class 1, Class 2, Class 3) are greater than .05. Therefore, the students in these classes were selected randomly (Table 1).

Table 1

The Run-Test to Confirm the Randomness of the Sample

Class	N	Mean	SD	Z	Sig. (2-tailed)
1	37	23.03	13.08	-0.663	0.507
2	17	53.71	5.89	0.015	0.988
3	21	75.71	6.91	-0.438	0.661

Hypothesis 1: There is a positive effect on students' mathematical performance.

Since the significance level of the Kolmogorov-Smirnov Test ($p > .05$) is greater than .05, the data distribution is normal. A Paired-Samples T-Test was used to determine the effect of training on the math test score (Table 2). The results indicate a significant difference between the math test scores before training ($M = 14.41$, $SD = 2.99$) and math test scores after training ($M = 17.20$, $SD = 2.73$); $t(74) = -8.037$, $p < .001$. Therefore, there is a positive effect of training on the math test score, and Hypothesis 1 is accepted. The effect size, as measured by Cohen's d, was -0.93, indicating a significant effect.

Table 2

The Paired-Samples T-Test for Pretest and Posttest

Variable	N	Mean	SD	t	df	Sig. (2-tailed)	d
Pretest	75	14.41	2.99				
Posttest	75	17.20	2.73				
Pretest-Posttest	75	-2.79	3.01	-8.037	74	<.001	-0.93

Hypothesis 2: The educational improvement of female students is less than that of male students.

The significance levels of the Kolmogorov-Smirnov Test ($p > .05$) show that the distributions of the dependent variables are normal. An Independent-Samples T-Test was used to compare the educational improvement for female and male students (Table 3). According to Levene's Test ($F = 0.449$, $p = 0.505$), there is no difference between the variances. There is no significant difference in academic improvement for females ($M = 2.27$, $SD = 2.88$) and males ($M = 3.49$, $SD = 3.07$); $t(73) = -1.770$, $p = .081$. These results suggest that the educational progress of females and males is equal, so Hypothesis 2 is not accepted. The effect size, as measured by Cohen's d, was -0.41, indicating a medium effect.

Table 3

The Independent-Samples T-Test for Females and Males Progress

Variable		N	Mean	SD	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	d
Progress	Female	43	2.27	2.88						
	Male	32	3.49	3.07						
	Total	75			0.449	0.505	-1.770	73	0.081	-0.41

Hypothesis 3: The educational improvement of extroverted students is more than that of introverts.

The significance levels of the Kolmogorov-Smirnov Test ($p > .05$) indicate that the distributions of the dependent variables are normal.

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An Independent-Samples T-Test was conducted to compare the educational improvement for introverted and extroverted students (Table 4). According to Levene's Test (F = 0.903, p = 0.345), there is no difference between the variances of the two groups. There is a significant difference in the educational improvement for introverted students (M = 2.10, SD = 3.06) and extroverted students (M = 4.36, SD = 2.24); t(73) = -3.186, p = .002. These results suggest that the academic progress of extroverts is more significant than that of introverts, so Hypothesis 3 is accepted. The effect size, as measured by Cohen's d, was -0.80, indicating a significant effect.

Table 4

The Independent-Samples T-Test for Introverts and Extroverts Progress

Variable		N	Mean	SD	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	d
Progress	Introvert	52	2.10	3.06						
	Extrovert	23	4.36	2.24						
	Total	75			0.903	0.345	-3.186	73	0.002	-0.80

Hypothesis 4: The educational improvement of extroverts is more than introverts among just female students.

The output of the Kolmogorov-Smirnov Test shows that the distributions of the dependent variables are normal (p > .05). An Independent-Samples T-Test was conducted to contrast the educational improvement for introvert and extrovert females (Table 5). According to the Levene's Test result (F = 2.317, p = 0.136), there is no difference between the variances. There is a significant difference in the educational improvement for introverted students (M = 1.68, SD = 3.11) and extroverted students (M = 3.62, SD = 1.70); t(41) = -2.099, p = .042. These results suggest that the academic progress of extrovert females is more significant than that of introverted females, so Hypothesis 4 is accepted. The effect size, as measured by Cohen's d, was -0.70, indicating a significant effect.

Table 5

The Independent-Samples T-Test for Introvert and Extrovert Females Progress

Variable		N	Mean	SD	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	d
Progress	In-Female	30	1.68	3.11						
	Ex-Female	13	3.62	1.70						
	Total	43			2.317	0.136	-2.099	41	0.042	-0.70

Hypothesis 5: The educational improvement of extroverts is more than introverts among just male students.

The results of the Kolmogorov-Smirnov Test (p > .05) show that the distributions of the dependent variables are normal. An Independent-Samples T-Test was conducted to compare the educational improvement for introvert and extrovert males (see Table 6). According to Levene's Test (F = 0.100, p = 0.754), there is no difference between the variances in the two groups. There is a significant difference in the educational improvement for introverted students (M = 2.66, SD = 2.96) and extroverted students (M = 5.32, SD = 2.56); t(30) = -2.453, p = .020. These results suggest that the academic progress of extrovert males is more significant than that of introvert males, so Hypothesis 5 is accepted. The effect size, as measured by Cohen's d, was -0.94, indicating a significant effect.

Table 6

The Independent-Samples T-Test for Introvert and Extrovert Males Progress

Variable		N	Mean	SD	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	d
Progress	In-Male	22	2.66	2.96						
	Ex-Male	10	5.32	2.56						
	Total	32			0.100	0.754	-2.453	30	0.020	-0.94

Hypothesis 6: The lecturer's scaffolding leads to an improvement in students' MMP.

Since the significance level of the Kolmogorov-Smirnov Test (p > .05) is greater than .05, the data distribution is

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normal. A Paired-Samples T-Test (see Table 7) was conducted to determine the effect of the scaffolding on MMP. The results indicate a significant difference between MMPB (M = 8.35, SD = 3.59) and MMPA (M = 15.43, SD = 4.34); t(74) = -16.603, p < .001. Therefore, the scaffolding has a positive effect on MMP, so Hypothesis 6 is accepted. The effect size, as measured by Cohen's d, was -1.92, indicating an extra-large effect.

Table 7

The Paired-Samples T-Test for MMPB and MMPA

Variable	N	Mean	SD	t	df	Sig. (2-tailed)	d
MMPB	75	8.35	3.59				
MMPA	75	15.43	4.34				
MMPB-MMPA	75	-7.08	3.69	-16.603	74	<.001	-1.92

Hypothesis 7: The changes in MMP of introverted students are more than that of extroverts.

Since the significance levels of the Kolmogorov-Smirnov Test are (p > .05), the data distribution is normal. An Independent-Samples T-Test was conducted to compare the effect of the scaffolding on the MMP of introvert and extrovert students (see Table 8). According to Levene's Test (F = 0.555, p = 0.459), there is no difference between the variances. There is a significant difference in MMP of the introverted students (M = 7.67, SD = 3.73) and the extroverts (M = 5.75, SD = 3.30); t(73) = 2.123, p = .037. These results suggest that the MMP of introverts is greater than that of extroverts, so Hypothesis 7 is accepted. The effect size, as measured by Cohen's d, was 0.53, indicating a medium effect.

Table 8

The Independent-Samples T-Test for Introverts' and Extroverts' MMP Progress

Variable		N	Mean	SD	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	d
MMP	Introvert	53	7.67	3.73						
	Extrovert	23	5.75	3.30						
		74			0.555	0.459	2.123	73	0.037	0.555

Hypothesis 8: The changes in MMP among female students are more than males.

The results of the Kolmogorov-Smirnov Test (p > .05) show that the distributions of the dependent variables are normal. An Independent-Samples T-Test (Table 9) was conducted to compare females and males' MMP. According to Levene's Test result (F = 0.168, p = 0.683), there is no difference between the variances. There is no significant difference between the MMP of females (M = 7.48, SD = 3.70) and male students (M = 6.55, SD = 3.68); t(73) = 1.080, p = .284. Therefore, the MMPs of the two groups are equal, and Hypothesis 8 is rejected. The effect size, as measured by Cohen's d, was 0.25, indicating a small effect.

Table 9

The Independent-Samples T-Test for the Females' and Males' MMP Progress

Variable		N	Mean	SD	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	d
MMP	Female	43	7.48	3.70						
	Male	32	6.55	3.68						
		75			0.168	0.683	1.080	73	0.284	0.25

Hypothesis 9: The companionship of extrovert students is more than introverts.

Since the significance levels of the Kolmogorov-Smirnov Test (p < .05) are smaller than .05, the data distribution is not normal. A Mann-Whitney U Test was used to determine whether there was a difference in the companionship of introverts and extroverts (see Table 10). The results indicate non-significant differences between groups (U = 437.000, Z = -1.876, p = 0.061). Therefore, there is no difference in the companionship of introverts and extroverts, and Hypothesis

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9 is rejected. By using U = 437.000, Z = -1.876, and n1 = 52, n2 = 23, the effect size is small (r = .21).

Table 10

The Mann-Whitney U Test for Introverts' and Extroverts' Companionship

Variable		N	Mean Rank	Mann-Whitney U	Z	Sig. (2-tailed)
Comp	Introvert	52	34.90			
	Extrovert	23	45.00			
		75		437.000	-1.876	0.061

Hypothesis 10: The companionship of female students is more than that of males.

The results of the Kolmogorov-Smirnov Test ($p < .05$) show that the distributions of the dependent variables are not normal. A Mann-Whitney U test was used to determine whether there was a difference in the companionship of females and males (see Table 11). The results indicate non-significant differences between groups (U = 644.500, Z = -0.473, p = 0.637). Therefore, there is no difference in the companionship of females and males, and Hypothesis 10 is not accepted. By using U = 644.500, Z = -0.473, and n1 = 43, n2 = 32, the effect size is very small (r = .06).

Table 11

The Mann-Whitney U Test for Females' and Males' Companionship

Variable	Gender	N	Mean Rank	Mann-Whitney U	Z	Sig. (2-tailed)
Comp	Female	43	36.99			
	Male	32	39.36			
		75		644.500	-0.473	0.637

4. Discussion and Conclusion

The results of this study provide compelling evidence for the effectiveness of the Flipped Learning method combined with the DISC Personality Test and lecturer scaffolding in enhancing undergraduate students' mathematical performance. The findings align with and extend previous research on innovative teaching methodologies in higher education.

The first research question (RQ1) investigated the overall impact of the Flipped Learning method on students' mathematical performance. The results showed a significant improvement in posttest scores compared to pretest scores, supporting the hypothesis that the Flipped Learning method positively affects students' mathematical performance. This is consistent with the findings of Fernández-Martín et al. (2020), who reported that the Flipped Classroom method significantly improved students' understanding and attitudes towards mathematics. Similarly, Lo, Hew, and Chen (2017) found that Flipped Learning provides more classroom time for active learning, which enhances student performance.

The second research question (RQ2) examined gender differences in educational improvement. The results indicated no significant difference between the academic progress of female and male students, suggesting that the Flipped Learning method benefits both genders equally. This finding aligns with the study by Sopamena et al. (2023), which demonstrated that the Flipped Classroom model is effective across different student demographics (Sopamena et al., 2023).

The third research question (RQ3) explored differences in educational improvement between introverted and extroverted students. The results indicated that extroverted students showed significantly greater academic progress compared to introverted students. This finding can be explained by the nature of the Flipped Learning method, which emphasizes active participation and interaction, conditions under which extroverts typically thrive. Dian Martha et al. (2023) emphasized the importance of motivational scaffolding, which could further support extroverted students' engagement and performance (Dian Martha et al., 2023).

The fourth research question (RQ4) focused on gender differences among extroverted and introverted students. The results showed that extroverted female students demonstrated significantly greater academic improvement than their introverted counterparts. This finding suggests that the interactive components of the Flipped Learning

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method may be particularly beneficial for extroverted females, aligning with the findings of Hastuti (2020) who reported increased enjoyment and engagement in mathematics among students using group-based learning strategies (Hastuti, 2020).

The fifth research question (RQ5) revealed that extroverted male students also showed significantly greater academic progress than introverted male students. This result reinforces the idea that extroverts, irrespective of gender, benefit more from the interactive and participatory nature of the Flipped Learning method. This is in line with the findings of Johnson (2020), who noted that active learning environments can significantly shape students' attitudes and performance in mathematics (Johnson, 2020).

The sixth research question (RQ6) investigated the impact of the lecturer's scaffolding on students' Mathematical Mind Processing (MMP). The results indicated a significant improvement in MMP post-scaffolding, confirming the hypothesis. Acosta-Gonzaga and Ramirez-Arellano (2022) highlighted the critical role of scaffolding in enhancing student motivation, engagement, and learning outcomes, supporting our findings (Acosta-Gonzaga & Ramirez-Arellano, 2022).

The seventh research question (RQ7) examined the differences in MMP improvements between introverted and extroverted students. The results showed that introverted students exhibited greater MMP improvement compared to extroverted students. This finding suggests that while extroverts may excel in active participation, introverts benefit more from structured support and guided learning, which enhances their cognitive processing. Alipour and Alipour (2022) emphasized the importance of personalized learning approaches, which can cater to the unique needs of introverted students (Alipour & Alipour, 2022).

The eighth research question (RQ8) focused on gender differences in MMP improvements. The results indicated no significant difference between female and male students, suggesting that scaffolding benefits students equally regardless of gender. This finding is consistent with Al-Rawi (2013), who noted that effective teaching methodologies can enhance learning outcomes across diverse student groups (Al-Rawi, 2013).

The ninth research question (RQ9) investigated differences in companionship between introverted and extroverted students. The results showed no significant difference, indicating that both groups engage similarly in collaborative activities when appropriately scaffolded. This finding aligns with Jakobsen and Knetemann (2017), who reported that structured team-based learning can foster positive interactions among all students (Jakobsen & Knetemann, 2017).

The tenth research question (RQ10) examined gender differences in companionship. The results indicated no significant difference between female and male students, suggesting that the scaffolding approach promotes equal engagement in collaborative activities. This is supported by Thi Mai Huong (2022), who highlighted the necessity of inclusive teaching practices that foster engagement among all students (Thi Mai Huong, 2022).

5. Limitations & Suggestions

This study has several limitations. First, the sample size was relatively small and limited to a specific university and discipline, which may affect the generalizability of the findings. Future research should include larger and more diverse samples across various educational settings and subjects to validate the results. Second, the study relied on self-reported data for some measures, which may introduce response bias. Employing more objective assessment tools could enhance the accuracy of the findings. Additionally, the study duration was relatively short, focusing on immediate academic performance. Longitudinal studies are needed to examine the long-term effects of the Flipped Learning method and scaffolding on student outcomes.

Future research should explore the impact of the Flipped Learning method and scaffolding across different educational levels and disciplines. Investigating the method's effectiveness in primary and secondary education could provide valuable insights into its broader applicability. Moreover, examining the role of technology in enhancing the Flipped Learning experience, such as the use of advanced digital platforms and interactive tools, could further improve student engagement and performance. Research should also consider the socio-cultural context of learners, as cultural factors may influence the effectiveness of teaching methods. Comparative studies between different cultural settings could shed light on how to tailor the Flipped Learning approach to diverse educational environments.

Educators should consider integrating the Flipped Learning method with scaffolding to enhance student engagement and performance. Providing structured support and guided learning activities can cater to diverse student needs, particularly benefiting both introverted and extroverted learners. Teachers should also leverage technology to create interactive and accessible learning

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materials, encouraging students to actively participate in their learning process. Training programs for educators on effective implementation of the Flipped Learning method and scaffolding techniques could further improve teaching practices. Additionally, creating a supportive and inclusive classroom environment that fosters collaboration and interaction among all students is crucial for maximizing the benefits of these innovative teaching methods.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

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