



Effectiveness of Flipped Teaching and Problem-Solving Methods on Problem-Solving Ability and Sense of Responsibility among Female High School Students

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Abstract

developing, and perfecting educational programs. The present study aimed to investigate the effectiveness of flipped teaching and problem-solving methods on the sense of responsibility and problem-solving ability in mathematics among female high school students in Ahvaz. The research method was quasi-experimental with a pre-test and post-test design and a control group. The statistical population included all female high school students in Ahvaz in 2019. Using the convenience sampling method, 75 students were selected and randomly divided into two experimental groups (flipped teaching and problem-solving method) and a control group (n= 25 per group). The control group received the traditional teaching method. The research instruments included the Responsibility Questionnaire and Problem-Solving Style Questionnaire. Analysis of covariance was used to analyze the data. The results showed that there was a significant difference between the experimental and control groups in productive and unproductive problem-solving styles among the students ($p < 0.01$). Also, the flipped teaching and problem-solving methods increased the sense of responsibility in the students, compared to the traditional method. According to the results, the effectiveness of flipped teaching was more effective compared to problem-solving methods on the productive and unproductive problem-solving styles and sense of responsibility. Consequently, the flipped teaching and problem-solving methods can be used to promote problem-solving styles and a sense of responsibility among students.

Keywords: Flipped teaching, mathematics, problem-solving, sense of responsibility

Introduction[#]

Nowadays, mathematics does not have the place it deserves among many students. Little attention is paid to this course of study despite its great importance. This is a major irrevocable flaw in the educational system in many countries. Various obstacles and difficulties render ineffective efforts to improve the math teaching quality in schools and even universities (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). The role of

teachers in teaching is not limited to transferring scientific facts to students; it also includes creating an optimal environment for learning and teaching them how to think and learn (Joubert, Callaghan, & Engelbrecht, 2020). Identifying the contributors to students' academic performance and progress creates an approach for planning, developing, and perfecting educational programs that obtain the best possible outcomes for students and educational development (Keller, Becker, Frenzel, & Taxer, 2018).

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On this basis, when learners are faced with a situation which they cannot quickly respond to using the information and skills they have at the moment, or when they have a goal and have not yet found the way to achieve it, they are facing a problem (Dabaghi, Hashemi, & Khademi Ashkzari, 2019; Rapanta, Botturi, Goodyear, Guàrdia, & Koole, 2020). Based on this definition, problem-solving can be defined as identifying and using the knowledge and skills that lead the learner to a correct response to the situation or the desired goal. Therefore, the essential point in problem-solving is applying the previously learned knowledge and skills to new situations (Ebrahimi Zarandi, Manzari Tavakoli, Manzari Tavakoli, & Zeinaddini Meimand, 2020; Liljedahl, Santos-Trigo, Malaspina, & Bruder, 2016). Nezu (2004) defined problem-solving as a self-directed cognitive behavioral process by which an individual tries to discover effective or adaptive solutions to specific problems of everyday life. Nguyen, Tran, and Nguyen (2021) showed that problem-solving in education helps improve the students' learning quality and brings students to independence and self-sufficiency in solving real-life problems.

Problem-solving is a self-directed cognitive-behavioral process whereby an individual tries to find ways to effectively deal or cope with problems in everyday life. According to this view, problem-solving is primarily a conscious, rational, active, and objective coping process that can enhance one's ability to effectively engage with a wide range of stressful situations. In general, it consists of a sequence of behavioral responses and cognitive and affective actions that have been oriented toward a specific goal to adapt to internal or environmental engagements (Nezu, Nezu, & D'burilla, 2017). Problem-solving is made up of two components: problem orientation and problem-solving skills. Problem orientation constitutes the motivational component of problem-solving. In other words, it refers to a set of generalized cognitive-affective (emotional)-behavioral responses that the individual conveys to the present problematic situation (D'Zurilla, Nezu, & Maydeu-Olivares, 2004).

In general, this component derives from problem-solving experiences in the past. Problem orientation is closely associated with positive and negative affect. Thus, negative problem orientation is associated with high negative affection and consequently low psychological health (Gonzalez, Ibáñez, & Barrera, 2017). On the other hand, positive orientation increases the individual's ability to circumvent the negative states—thereby facilitating problem-solving and promoting psychological well-being. Individuals' orientation towards the problem is indirectly related to their mental health (Ghadiri Bahramabadi, Michaeli

Manee, & Issazadeghan, 2015). Garibi and Bahari Zar (2016) indicated that teaching problem-solving skills improved academic enthusiasm, student-teacher relationship, and life satisfaction in female students. Gharibi (2018) reported that students' responsibility increased significantly after learning problem-solving skills. Albay (2019) found that the problem-solving method improved this skill in students more than did the inquiry-based method.

The main elements of responsibility are self-awareness, accepting the consequences of one's behavior, self-assessment, planning, and self-control (Serrat, 2017; Taher Soltani, Jomehri, & Bagheri, 2020). Wonicki (2014) believed that humans' problems and misbehaviors stem from not taking responsibility, as they fail to fulfill their basic needs based on appropriate and humane conditions. The first aspect of responsibility is a cognitive one. Each individual in society communicates with the world around him in a particular manner. However, the important point is their understanding of the world around them. Naturally, responsible social behavior is achieved only when individuals have a correct understanding of society and the importance of their behaviors in preserving it. The second fundamental aspect in promoting responsibility is striving to create positive motivation, attitude, and emotion towards different types of responsibility. Emotions such as satisfaction, interest, enthusiasm, and happiness are among the most positive and effective contributors to acting responsibly. There are also negative emotions affecting responsible behavior such as anxiety, distress, anger, rebellion, hatred, contempt, fear, shame, and blame (Wonicki, 2014).

Responsibility, like any attribute, has certain signs and results that benefit anyone who acquires it. Some of the hallmarks of responsibility include: An optimal use of one's time and doing personal tasks as well as possible, doing tasks in an orderly manner, asking for other people's help, choosing one's friends wisely, an active presence at home, and in school, considering one's family's financial state, avoiding profusion, apologizing after making a mistake, showing concern to surrounding issues, keeping promises, a critical view of subjects, etc. (Helker & Wosnitza, 2014; Lewis, 2001). Bachiller and Badía (2020) showed that flipped education has a positive impact on the sense of responsibility in students. Chinaveh (2013) reported that problem-solving training raises an individual's responsibility for his well-being and social adjustment.

The flipped classroom is a new teaching and learning approach based on IT and communication technology that changes the traditional classroom in creative ways. In this method, the teacher provides the learners with the lessons before teaching them. The students are required

to learn the materials individually in places other than the classroom — i.e., home — by watching videos, experimenting, listening to audio files, or using other items provided by the teacher for improved learning of the subject and then attend the class (Argaw, Haile, Ayalew, & Kuma, 2017; Khayat, Hafezi, Asgari, & Talebzadeh Shoushtari, 2020). The classroom, therefore, will become a place for having knowledge-based conversations, asking and answering questions, correcting mistakes, and doing exercises. Therefore, students who practice active learning through the flipped classroom approach are actively involved in this process instead of being passive listeners and find themselves responsible for the acquisition of knowledge. As result, they learn better and enjoy this process more (Fallah, Hafezi, Makvandi, & Bavi, 2020). Bhagat, Chang, and Chang (2016) showed that flipped teaching had a positive impact on math learning and students' academic enthusiasm and self-efficacy. Ekmkkci (2017) in a study based on cognitive styles on the impact of the flipped classroom method on students in language training and their writing achievements found that the average score of students in the test group was significantly higher than that of the students in the control group.

Evaluation and explanation of flipped teaching and problem-solving methods on improving problem-solving ability and sense of responsibility among female high school students are among the most important innovations of this study. It should be stated that this research was necessary due to the paucity of studies on problem-solving ability and sense of responsibility of female high school students. Accordingly, the present study aimed to investigate the effectiveness of flipped teaching and problem-solving methods on the sense of responsibility and problem-solving ability in mathematics among female high school students in Ahvaz.

Methods

The research method was quasi-experimental with a pre-test and post-test design and a control group.

Participants

The statistical population comprised of all female high school students in Ahvaz in 2019. Using the convenience sampling method, 75 students were selected and randomly divided into two experimental groups (flipped teaching and problem-solving method)

and a control group. Twenty-five students were included in each group by use of G*Power software and based on Afroudeh and Saidzanozi (2017) study. Inclusion criteria were: age range between 12 and 14 years and lack of severe physical or mental problems. The exclusion criteria were more than two absences from the training sessions and reluctance to continue the treatment process.

Instruments

The Responsibility Questionnaire: The responsibility questionnaire was comprised of 15 items and formulated in by Nemati in 2007. The scoring in this questionnaire includes items with five options, ranging from "absolutely agree" to "absolutely disagree". Scoring follows the 1–5-point method. Of all the questions, 30 are answered directly and 20 in reverse (Jowkar et al., 2019). The correlation coefficients obtained in Jowkar, Fooladchang, Anjomshoa, and Korhani (2019) were reported as: self-management 0.78, orderliness 0.86, lawfulness 0.80, trustworthiness 0.55, conscientiousness 0.53, organization 0.60, progressivism 0.52; all indicating the questionnaire's sufficient reliability. The Cronbach's alpha coefficient was 0.92 in the present study.

The Problem-solving Style Questionnaire: This questionnaire was formulated by Cassidy and Long (1996) and includes 24 questions that evaluate six factors. They include helplessness, problem-solving control, creative problem-solving style, problem-solving confidence, avoidance style, and approach style. The sub-scale coefficients for the first and second study by Cassidy and Long (1996) were respectively reported as follows: helplessness 0.66 and 0.86, problem-solving control 0.66 and 0.60, creative problem-solving style 0.57 and 0.66, problem-solving confidence 0.66 and 0.71, avoidance style 0.52 and 0.51, and approach style 0.56 and 0.53. In the current study, the Cronbach's Alpha coefficient for the entire questionnaire was 0.76.

Flipped Teaching Protocol: The protocol was made by Bergman and Sams (2015) and presented to the students over eight 90-minute sessions. After confirming the face and content validity, the protocol has been used in different studies. Khayat et al. (2020) also used flipped teaching to improve the students' educational performance and motivation. Fallah et al. (2020) also used this method to improve the remembering ability of middle school students. Table 1 presents summary of sessions.

Table 1.*Summary of Flipped Classroom Sessions (Khayat et al., 2020)*

Session	Content of Sessions
1	Online teaching, including sending educational videos and images related to the lesson topics in the class group in WhatsApp and Shad applications.
2	Evaluate the topics of the previous session and answer students' questions, conduct brainstorming discussions.
3	Online teaching, using educational clips and pictures in teaching.
4	Send short and attractive educational videos. Encourage students to ask questions related to the topics.
5	Perform assigned tasks, questions and answers, provide functional assignments.
6	Online teaching, sending short texts with pictures.
7	Online teaching, sending pictures and presenting practical problem
8	Evaluation of the topics of the previous sessions, presenting the students' reports about solving the assignments, and final review of the reports and feedback of the previous sessions.

Problem-solving Training Protocol: The protocol was made by D'Zurilla and Goldfried's in 1971 and presented to the students over eight 90-minute sessions. After confirming the face and content validity, the protocol has been used in different studies. The summary of problem-solving training protocol sessions was as follows: Session 1: Completing the questionnaires and justifying the students about the protocol. Session 2: Orientation (the first step of problem-solving). Session 3: Strengthen the orientation phase. Session 4: Defining the problem. Session 5: Generating alternative solutions. Session 6: Decision-making. Session 7: Implement the appropriate solution. Session 8: Emphasis on instrumental-objective thinking and review. Tajeri (2016) used problem-solving skills training to improve students' inter-personal sensitivity and aggression. In addition, Garibi and Bahari Zar (2015) used problem-solving training protocol to improve students' educational self-regulation and anxiety.

Procedure

The pre-test was performed for all 3 experimental and control groups before the intervention program. The first experimental group received the flipped teaching eight 90-minute sessions per week, and the second experimental group underwent eight sessions of problem-solving methods (90-minute sessions per week). The control group received the traditional teaching method. After the end of the intervention program, post-test was performed on both experimental groups and a control group. To take ethical

considerations into account, the researchers received written consent from the participants for participation in the research.

Data Analysis

Descriptive and inferential statistics such as mean, standard deviation, univariate analysis of covariance (ANCOVA), and multivariate analysis of covariance (MANCOVA) were used to analyze the Data. Besides, data analysis performed using SPSS Statistics software.

Findings

The participants included 75 female high school students, aged 15.68 ± 2.72 years. Table 2 presents the mean and standard deviation (SD) of the pre-test and post-test scores of productive and unproductive problem-solving styles and sense of responsibility for the experimental and control groups. Mean \pm SD of the productive problem-solving styles for the flipped teaching, problem-solving method, and control groups in the post-test phase were 13.98 ± 4.19 , 14.22 ± 4.31 , and 9.91 ± 4.47 , respectively. Mean \pm SD of the unproductive problem-solving styles for the flipped teaching, problem-solving method, and control groups in the post-test phase were 8.85 ± 3.76 , 8.12 ± 4.43 , and 13.03 ± 4.25 , respectively. Furthermore, the mean \pm SD of the sense of responsibility for the flipped teaching, problem-solving method, and control groups in the post-test phase were 168.85 ± 16.17 , 170.54 ± 16.45 , and 142.36 ± 15.91 , respectively (Table 2).

Table 2.*Mean and Standard Deviation of the Variables in Experimental and Control Groups in Pre-Test and Post-Test*

Variables	Phase	Flipped teaching	Problem-solving method	Control
		M ± SD	M ± SD	M ± SD
Productive problem-solving styles	Pre-test	10.25 ± 4.97	10.14 ± 4.35	9.89 ± 4.34
	Post-test	13.98 ± 4.19	14.22 ± 4.31	9.91 ± 4.47
Unproductive problem-solving styles	Pre-test	13.27 ± 5.12	13.41 ± 5.37	13.08 ± 5.61
	Post-test	8.85 ± 3.76	8.12 ± 4.43	13.03 ± 4.25
Sense of responsibility	Pre-test	140.23 ± 16.32	138.47 ± 16.21	140.38 ± 15.48
	Post-test	168.85 ± 16.17	170.54 ± 16.45	142.36 ± 15.91

According to Table 3, the variances' homogeneity in the three groups was not significant for all research variables. Therefore, the null hypothesis was confirmed for the three groups' variance homogeneity scores for

the variables. Furthermore, the amount of F interaction for all the research variables was insignificant. Therefore, homogeneity of regression was assumed (Table 4).

Table 3.*Levene's Test Results on the Assumption of The Equality of Variances of Research Variables*

Variables	F	df1	df2	P
Productive problem-solving styles	1.41	2	72	0.241
Unproductive problem-solving styles	1.16	2	72	0.322
Sense of responsibility	1.92	2	72	0.173

Table 4.*The Results of the Homogeneity of Pre-Test and Post-Test Regression Slope in the Experimental and Control Groups*

Source of changes	Variables	F	P
Group * Pre-test	Productive problem-solving styles	1.51	0.361
	Unproductive problem-solving styles	1.32	0.245
	Sense of responsibility	1.21	0.345

According to Table 5, by controlling the pre-test between the students of the experimental and control groups, a significant difference was observed in

productive and unproductive problem-solving styles and sense of responsibility ($p < 0.01$).

Table 5.*The Results of Univariate ANCOVA for Post-Test Scores of the Research Variables*

Variables	SS	df	MS	F	P	η^2	Power
Productive problem-solving styles	1028.16	2	514.08	15.32	0.0001	0.401	1.00
Unproductive problem-solving styles	868.98	2	434.49	13.95	0.0001	0.392	1.00
Sense of responsibility	2146.68	2	1073.34	14.96	0.0001	0.360	0.99

Discussion

The present study aimed to investigate effectiveness of flipped teaching and problem-solving methods on students' problem-solving ability and sense of responsibility in mathematics. The results showed that the students in the test and control groups were significantly different in one of the dependent variables

for problem-solving (productive and unproductive styles) and the sense of responsibility. Moreover, the effectiveness of flipped teaching and problem-solving methods on the productive and unproductive problem-solving styles and responsibility were different. According to research literature, no study has yet been done on this subject; however, the findings are implicitly consistent with the results of Adib Neia, Mohajer, and

Sheikhpour (2013), Gharibi (2018), Hendriana, Johanto, and Sumarmo (2018), Kwok, Yeung, Low, Lo, and Tam (2015), Politsinsky, Dmnankvva, and Medvedvva (2015), Reich, Blackwell, Simmons, and Beck (2015), and Sojayapan and Khlaisang (2020).

Adib Neia et al. (2013) also showed that problem-solving teaching method and inquiry-based teaching method contribute to students' problem-solving skills. Hendriana et al. (2018), indicated that problem-based learning improved the students' mathematical problem solving. Moreover, Kwok et al. (2015) found that problem-solving training enhanced the individuals' responsibility with respect to well-being and social adjustment abilities. In explaining these findings, flipped teaching is a relatively new approach that engages students in learning, and if they are meaningfully involved in the learning and evaluation process, they will succeed further in the mental development of knowledge (Sojayapan & Khlaisang, 2020). In flipped classes, time pressure is less of an issue and teachers can easily implement active learning strategies. Also, implementing active learning increases student participation and collaborative learning. Since learning occurs outside the classroom through textbooks, movies, animations, and audio files, the new method — which makes learning independent of time and place — has an advantage over traditional education. As a result, learning can occur continuously. Furthermore, the student's absence from the classroom has a limited effect on their learning as they will be able to adapt to the conditions using textbooks, instructional movies, slides, podcasts, etc. As students receive the concepts through a variety of senses, it results in deeper learning and they will remember the lessons for a longer time. Therefore, it can be stated that flipped teaching can impact the students' problem-solving skills and sense of responsibility.

The results of the study showed that the problem-solving teaching method led to a significant improvement in problem-solving and responsibility scores for the test groups compared to the control group; i.e., those who received this training scored higher in problem solving and responsibility than those who did not receive the intervention. This suggests that the method has made the students more effective in problem-solving and responsibility and more responsive to and interested in education.

Since the present study was performed on female high school students in Ahvaz, caution should be observed in generalizing the results to other communities in different time and place situations due to different cultural conditions.

Conclusion

According to the study findings, flipped teaching and problem-solving methods had a positive effect on problem-solving ability and sense of responsibility among female high school students. Problem-solving skills will enable students to accept the situations rather than avoiding them and feel a sense of belonging to situations and tasks. It improves problem-solving, self-confidence, and efficacy in people helping them engage in everyday challenges with a greater sense of security. Since these results were confined to girls, it is suggested the research also be done on boys. A study should be done on the satisfaction level of those who received the flipped teaching and problem-solving training methods. Moreover, this study focuses on the acquisition of mathematical studies and it is suggested that similar studies be carried out on other school subjects and grades.

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Conflict of Interest

No conflicts of interest declared.

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