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Success in Science: The effect of Bybee's 5E Model on Academic Self-Efficacy and Academic Engagement for Bushehr 6th Grade Students

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ABSTRACT

Objective: he objective of this study was to investigate the impact of the Bybee five-step model (5E) teaching method on the academic engagement and academic self-efficacy of 6th grade students in experimental sciences in Bushehr.

Methods: The research design employed was quasi-experimental, using a pre-test and post-test design with a control group. The statistical population consisted of 671 sixth grade students in Bushehr city during the academic year of 2022. The sample size of the study consisted of 30 individuals who were selected using the accessible sampling method and were divided into two groups: experimental and control. The research instruments used were Rio's (2013) academic engagement questionnaires and Jing and Morgan's (1999) academic self-efficacy questionnaires.

Results: The findings of the study revealed that the implementation of Bybee's five-step model (5E) training enhanced each component of academic engagement, namely behavioral engagement, agent engagement, cognitive engagement, and emotional engagement, in the experimental group compared to the control group. Furthermore, the teaching method based on the five-step Bybee model (5E) improved each component of academic self-efficacy, including aptitude, context, and effort, in the experimental group compared to the control group.

Conclusions: In conclusion, this research highlights the significance of incorporating innovative educational methods that encourage critical thinking, foster effective learning, and cultivate lifelong learners among students.

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Introduction

The significance of the science course is paramount among the various courses, as its reinforcement can greatly impact students' academic future. This particular lesson directly correlates with the surrounding environment of children, and when children are placed in an appropriate educational routine, they can acquire knowledge and experiences in experimental sciences from both living and inanimate beings in their surroundings. This lesson enables children to familiarize themselves with their environment and fosters the development of their self-efficacy and creativity (Azeimi, 2013). The science lesson imparts knowledge, skills, and attitudes to students, and its acquisition largely depends on the scientific activities of the students and the teaching methods employed. Teachers can simplify and make this lesson appealing to students by utilizing contemporary and age-appropriate techniques (Ahmadi, 2013).

Student academic engagement serves as a crucial indicator of educational quality. Academic conflict, initially conceptualized to comprehend and elucidate academic underachievement, has been deemed foundational for educational reform efforts (Van Youden, 2014). Academic engagement encompasses behavioral, cognitive, and motivational dimensions. The behavioral dimension pertains to observable academic behaviors, including effort and persistence when faced with homework challenges, as well as seeking assistance from professors or peers in order to comprehend and master course material (Clawson, 2017). The emotional dimension of academic engagement involves students' emotional reactions and responses within the classroom and school setting. Essentially, emotional engagement encompasses internal interest in the content and homework, valuing the subject matter, experiencing positive emotions, and the absence of negative emotions such as frustration, anxiety, and anger during homework completion and learning (Pinten, 2019). Additionally, cognitive and metacognitive strategies constitute the various processing techniques employed by students for learning, and are integral components of academic engagement (Ismailzadeh Ashini, 2018). Recently, another dimension called agency has been incorporated into the concept of academic engagement, denoting the active and constructive participation of learners in their educational experiences (Askari, 2018). This form of engagement emphasizes the intentional and proactive efforts of learners to personalize and optimize the learning process, as well as the learning conditions and contexts (Parhiz, 2014). Students should consistently engage with their homework in order to align their existing knowledge with current

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information and achieve academic progress. Therefore, it is essential to identify the factors that contribute to increased academic engagement among students and foster their development (Ramazani, 2016).

Academic self-efficacy is a variable that is associated with the progress of students and can significantly impact their lives. It refers to a person's ability to recognize their own capabilities in performing tasks necessary to achieve academic goals. Students who possess higher academic self-efficacy exhibit better adaptation to academic settings and employ more effective learning strategies (Ziegler, 2018). Essentially, academic self-efficacy represents an individual's belief in their capacity to organize and execute the required actions in future situations. In other words, it is the confidence one has in their ability to succeed in a given circumstance. According to Bandura, this belief is the determining factor in an individual's cognition, behavior, and emotions (Talsma, 2018). Specifically, academic self-efficacy reflects one's confidence in performing academic tasks such as reading, participating in class discussions, and preparing for exams (Mohammadi, 2019). Higher levels of academic self-efficacy are associated with better grades and a greater commitment to completing assignments, thus leading to improved academic adjustment. Perceived self-efficacy refers to an individual's assessment of their capabilities and skills to accomplish a specific activity and attain a desired outcome. Levels of self-efficacy can influence motivation, either increasing or decreasing it (Menshi, 2015). Students with high levels of self-efficacy are inclined to take on challenging assignments and do not shy away from them. Additionally, students' personal self-efficacy beliefs determine their motivation levels, influencing their perseverance and ability to overcome obstacles without giving up (Won, 2018).

Conversely, Bybee's model encompasses five stages aimed at acquiring new concepts or developing a deeper understanding of familiar concepts and topics. To achieve this profound comprehension, students draw on both past experiences and those acquired during the discovery phase (Newby, 2004). This model is not limited to everyday surface-level skills but is also applicable to the acquisition of high-level and professional skills, fostering advanced thinking (Asish, 2010). The first stage, goal activation, involves engaging learners' imagination (Bodi, 2003). During this phase, the teacher assesses the students' prior knowledge and assists them in grasping new concepts through a series of stimulating activities that arouse their curiosity (Bybee, 2009).

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Asking a question, defining a problem, showing an exciting event and... are the methods that arouse the student and make him dream about the desired problem (Razavi, 2018). The implementation of this stage is successful when students are actively motivated to research and learn (Bodi, 2003). In the second stage, which is discovery, students are given exploratory activities and they will be allowed to build their skills and concepts. They do things in which they also use their past knowledge. And they generalize their knowledge by using exploratory questions and conducting and designing experiments (Baybee, 2009). Finally, after the different groups explored, one of the members of each group writes down the description of the activities performed, the observations and the results obtained by the members of the group (Razavi, 2011). In the third stage, that is, the explanation stage, it is the stage in which the learner abstracts experiences; Learners are given an opportunity to explain their findings from the previous steps. These explanations should be related to activation and exploration activities as well as students' experiences (Bodi, 2003). The focus of this stage is on students' attention on a special aspect of the experiences they have gained in the previous stages and provides an opportunity for conceptual understanding. Show their abilities. At this stage, learners explain their understanding of the concepts, and the teacher's explanations can guide students to deeper learning (Bybee, 2009). In the fourth stage, i.e. the elaboration stage, students expand the concepts they have learned and by making connections between concepts, they apply what they have learned to the world around them (Razavi, 2019). are unable in different situations, students should be willing to associate their concepts with specific situations. This stage is necessary in showing different views of a phenomenon (Bodi, 2003). In the last stage, which is the evaluation stage, which is a continuous diagnosis process, it allows the teacher to find out about the level of students' understanding of new concepts and knowledge (Razavi, 2018) and also students are encouraged to question their own concepts. place (Budi, 2003). At this stage, students should evaluate their understanding and abilities. And it also provides an opportunity for the teacher to evaluate the progress of the students (Bybee, 2009).

The conducted researches have also emphasized the effectiveness of the teaching method based on Baybee's five-step model (5E), such as: Rostamnejad (2021), Radmehr (2021), Mousavi (2019), Mehrovarz (2015), Mehrovarz (2014), Zare (2014), Maliki (2012), Moradi (2011), Koparan (2023), Kaplan (2023), Hsiao (2023) and Fontes (2016) using educational methods from the five-stage model of Baybee, students can think deeply, learn how to learn, and become lifelong learners.

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Academic engagement and academic self-efficacy were examined as dependent variables in order to assess the impact of Baybee's five-step (5E) education method on these variables. The primary research question in this study is whether the teaching method rooted in Bayabee's five-stage model (5E) is efficacious in enhancing the academic engagement and academic self-efficacy of experimental science students in the 6th grade in Bushehr.

Materials and Methods

In this research, a quasi-experimental method was used with a pre-test and post-test design with a control group, in such a way that the experimental group was under the training method based on Bybee's five-step model (5E) and the control group was without training and consisted of 30 people who were accessible samples were selected and replaced in two experimental and control groups. The statistical population of the current study was 671 students of the sixth grade of Bushehr during the academic year of 2022. Among the criteria for entering the research included: the student's motivation to attend meetings regularly. Also, the criteria for leaving the research included: not attending more than two consecutive meetings, requesting non-cooperation by the individual, and lack of motivation to perform activities. In the discussion of ethical considerations, the subjects were assured that these questions are only for research purposes and there is no need to write names and surnames. On the other hand, the subjects' participation in the research is free and there is no compulsion. Also, the subjects were assured that they can leave the training sessions whenever they want. The research tools included Rio's (2013) academic engagement questionnaire and Jing and Morgan's (1999) academic self-efficacy questionnaire as follows.

Rio Academic Engagement Questionnaire (2013): Academic engagement questionnaire (2013) was designed and developed by Rio to measure academic engagement. This questionnaire has 17 questions and 4 components of behavioral engagement in questions 1 to 4, factor engagement in questions 5 to 9, cognitive engagement in questions 10 to 13, and emotional engagement in questions 14 to 17. Each question has 7 points, where strongly agree has 7 points and strongly disagree has 1 point. The questionnaire does not have a reverse score. By adding the score of each question, the score of each dimension is obtained, and the sum of the scores of all items is the total score of academic engagement. Rio (2013) reported the reliability of the questionnaire with the help of Cronbach's alpha coefficient of 0.86. Bandari (2017) reported the reliability of the

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questionnaire with the help of Cronbach's alpha coefficient of 0.81. Shenbadi (2018) reported the reliability of the questionnaire with the help of Cronbach's alpha coefficient of 0.78. Sadi (2018) reported the reliability of the questionnaire with the help of Cronbach's alpha coefficient of 0.83. The reliability of the questionnaire in the present study was obtained with the help of Cronbach's alpha coefficient of 0.80. The validity of this questionnaire was calculated using the correlation coefficients of each question with the total score and it showed that all questions have a significant correlation with the total score.

Jing and Morgan's Academic Self-Efficacy Questionnaire (1999): Jing and Morgan's Academic Self-Efficacy Questionnaire (1999) has 30 questions. This questionnaire has three subscales (talent 1 to 10, texture 11 to 20 and effort 21 to 30). The questions of this questionnaire are in the form of a two-point Likert scale (yes and no). This questionnaire is based on the Likert scale (I completely disagree 1, I disagree 2, I agree 3 and I completely agree 4). The scoring method of this questionnaire is that questions 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 21, 24, 25, 26, 28, 29 and 30, if the respondent marked completely agree, he gets 4, if he marked somewhat agree, he gets 3, if he marked somewhat disagree, he gets 2, if he marked completely disagree, he gets 1 And questions 4, 5, 15, 16, 19, 20, 22, and 23 are reversed, that is, if he marked completely against 4, somewhat against 3, somewhat agree 2, completely agree 1. If the scores of the questionnaire are between 30 and 52, the level of self-efficacy of the student in this society is weak. If the scores of the questionnaire are between 52 and 75, the student's self-efficacy is at an average level. If the scores are above 75, the student's self-efficacy is very good. The reliability of this questionnaire in the present study was reported using Cronbach's alpha coefficient of 0.82. The validity of this questionnaire was calculated using the correlation coefficients of each question with the total score and it showed that all questions have a significant correlation with the total score.

The protocol of teaching method based on Baybee's five-step model (5E): In this research, the teaching method based on Baybee's five-step model (5E) was presented to students during several sessions.

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Results

According to the information listed in Table 1, the normality of the data was discussed, and then in Tables 2 to 6, the hypotheses of the research were analyzed.

Table 1. Kolmogorov-Smirnov test results for normal distribution assumption

Variable	Phase	Statistic	P
Academic engagement	Experimental	0.12	0.20
	Control	0.19	0.12
Self-efficacy	Experimental	0.16	0.20
	Control	0.21	0.06

The results of the Kolmogorov-Smirnov test showed that the significance level for the variables of academic engagement and academic self-efficacy is greater than 0.05, so the Kolmogorov-Smirnov statistic for the variables is not significant at the 0.05 error level, and accordingly, the distribution of the variables is normal.

Table 2. Adjusted indicators related to academic engagement and each of its components, separately for the experimental and control groups in the post-test phase

Variable	Experimental group			Control group	
	Mean	SD	N	Mean	SD
Behavioral engagement	27.06	0.34	15	25.63	0.34
Agency engagement	15.66	0.59	15	12.83	0.59
Cognitive engagement	23.77	0.35	15	20.92	0.35
Emotional engagement	15.75	0.47	15	12.74	0.47

The results showed that the adjusted average score of each of the components of academic engagement, i.e., behavioral engagement, agent engagement, cognitive engagement, and emotional engagement in the subjects of the experimental group in the post-test stage is higher than that of the control group.

Table 3. Summary of the results of multivariate covariance analysis on the post-test scores of academic engagement and each of its components

Effect	Test	Value	F	DF1	DF2	P	Effect size
Group	Pillai's trace	0.53	8.94	4	21	0.001	0.53
	Wilks' lambda	0.46	8.94	4	21	0.001	0.53
	Hotelling's trace	1.15	8.94	4	21	0.001	0.53
	Roy's largest root	1.15	8.94	4	21	0.001	0.53

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The results of one-way covariance analysis in the MANCOVA show that in terms of behavioral engagement (F=24.9 and P<0.0001), agentic engagement (F=37.5 and P<0.0001), cognitive engagement (29.08 = F and P < 0.0001) and emotional engagement (F = 27.11 and P < 0.0001) there is a significant difference between the experimental group and the control group, in other words, the training method based on the five-step Bybee model (5E) causes the improvement of each of the components of academic engagement, i.e., behavioral engagement, agent engagement, cognitive engagement, and emotional engagement in the subjects of the experimental group compared to the control group.

Table 4. Results of one-way covariance analysis in MANCOVA related to components of academic engagement

Source	Variable	SS	DF	MS	F	P	Effect size
Group	Behavioral engagement	50.06	1	50.06	24.90	0.001	0.49
	Agency engagement	40.80	1	40.80	37.50	0.001	0.60
	Cognitive engagement	15.80	1	15.80	29.08	0.001	0.53
	Emotional engagement	12.20	1	12.20	27.11	0.001	0.53

The results showed that the average adjusted score of each of the components of academic self-efficacy, i.e. talent, texture and effort in the subjects of the experimental group in the post-test stage is higher than the subjects of the control group.

Table 5. Adjusted indicators related to academic self-efficacy and each of its components in the experimental and control group subjects in the post-test stage

Variable	Experimental		Control	
	Mean	SD	Mean	SD
Talent	35.47	0.96	32.99	0.96
Texture	46.43	0.81	43.56	0.81
Effort	17.71	0.46	16.29	0.46

The results of multivariate covariance analysis on the post-test scores with the pre-test score control showed that there is a significant difference between the experimental and control groups in terms of at least one of the components of academic self-efficacy, i.e. talent, texture and effort (P<0.0001). In other words, it can be said that the teaching method based on Baybee's five-step

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model (5E) has a significant effect on the components of academic self-efficacy, i.e. talent, texture and effort.

Table 6. Summary of the results of multivariate covariance analysis on the post-test scores of academic self-efficacy and each of its components

Effect	Test	Value	F	DF1	DF2	P	Effect size
Group	Pillai's trace	0.53	8.82	3	23	0.001	0.53
	Wilks' lambda	0.46	8.82	3	23	0.001	0.53
	Hotelling's trace	1.15	8.82	3	23	0.001	0.53
	Roy's largest root	1.15	8.82	3	23	0.001	0.53

Table 7. Results of one-way covariance analysis in MANCOVA

Source	Variable	SS	DF	MS	F	P	Effect size
Group	Talent	40.73	1	40.73	3.86	0.05	0.13
	Texture	54.67	1	54.67	5.83	0.02	0.18
	Effort	13.42	1	13.42	4.46	0.04	0.15

The results of one-way covariance analysis show that in terms of talent ($F=3.86$ and $P<0.05$), texture ($F=5.83$ and $P<0.023$) and effort ($F=4.46$ and ($P < 0.045$) there is a significant difference between the experimental group and the control group, in other words, the teaching method based on the five-step model of Bybee (5E) improves each of the components of academic self-efficacy, i.e. talent, texture and effort in the subjects of the group in experimental group compared with the control group.

Discussion

The current investigation aimed to examine the impact of the instructional approach based on Bybee's five-step model (5E) on the academic engagement and academic self-efficacy of sixth-grade students in Bushehr city during the experimental science course. The findings of the study revealed that the training based on Baybee's five-step model (5E) enhanced the various components of academic conflict, namely behavioral conflict, agential conflict, cognitive conflict, and emotional conflict, in the experimental group compared to the control group. Furthermore, the teaching method derived from the five-step Baybee model (5E) improved the different aspects of academic self-efficacy, including aptitude, context, and effort, among the experimental group compared to the control group.

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The results of this research are consistent with the findings of previous studies conducted by Rostam Nejad (2014), Radmehr (2014), Mousavi (2018), Mehrovarz (2014), Mehrovarz (2014), Zare (2014), Maliki (2014), Moradi (2011), Koparan. (2023), Kaplan (2023), Hsiao (2023), and Fontes (2016). The explanations provided indicate that the objective of Baybee's model in its five stages is to facilitate the acquisition of new concepts or enhance the understanding of familiar concepts and topics at a deeper level. In order to achieve this profound comprehension, students utilize both past experiences and experiences gained through the exploration phase. This model is not solely applicable to surface-level skills in everyday life but also contributes to the acquisition of advanced and professional skills, thereby enhancing higher-order thinking. On the other hand, every educational system aims to enhance students' performance in cognitive, emotional, and behavioral domains, as investing in this generation is crucial for building the future of the country. Consequently, identifying the dimensions that have an impact on educating young individuals holds great significance. Another factor influencing students' performance is their level of academic engagement, which can significantly influence the quality of their academic achievements. Academic engagement refers to the amount of effort students dedicate to targeted educational activities in order to actively contribute to the accomplishment of their academic objectives. Overall, academic engagement can be understood as the active involvement of individuals in the educational process, prompting students to establish a framework for themselves and strive towards achieving their ultimate goals within that framework.

The current investigation sought to examine the influence of the instructional approach centered on Baybee's five-step model (5E) on the scholarly involvement and scholarly self-efficacy of sixth-grade students in Bushehr city, specifically in the domain of experimental sciences. Findings from the study demonstrated that the training based on Baybee's five-step model (5E) enhanced each component of academic conflict, namely behavioral conflict, agential conflict, cognitive conflict, and emotional conflict, among the participants in the experimental group when compared to the control group. Moreover, the teaching method grounded in the five-step Baybee model (5E) enhanced each aspect of academic self-efficacy, including aptitude, context, and effort, among the participants in the experimental group when compared to the control group.

It is important to note that when a task holds meaning for a student and aligns with their long-term objectives, it captures their attention and leads them to invest time and effort into its completion.

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The student is driven by a sense of commitment to perform the task well and become engaged with it. This feeling of commitment fosters a student's persistence in completing the task and motivates them to devote more time to it. Therefore, attention and commitment are two crucial dimensions that significantly impact academic engagement. When a student becomes immersed in their academic activity or any other task, they lose track of time and derive enjoyment from the experience, resulting in heightened productivity and a sense of involvement. Furthermore, their enthusiasm for the subject matter or activity increases, encouraging them to continue their journey. On a different note, a child's academic self-efficacy strongly predicts their ability to form friendships during adolescence. Consequently, interventions aimed at enhancing children's social competence are imperative. Academic self-efficacy is rooted in the belief that one possesses the necessary skills and resources to effectively navigate challenging situations. Consequently, a sense of academic self-efficacy empowers students to employ their skills when faced with obstacles and achieve remarkable outcomes. Therefore, perceived academic self-efficacy plays a pivotal role in successful performance and the acquisition of fundamental skills required for accomplishment.

One of the limitations of this study is that the sample population was restricted, necessitating caution when generalizing the findings. Additionally, the duration of the training sessions sometimes leads to fatigue among students in the experimental group during their attendance. Thus, it is recommended to implement knowledge-enhancing programs focused on teaching methods based on Baybee's five-step model to determine the extent of their impact on academic engagement and academic self-efficacy in the field of experimental sciences. Furthermore, conducting similar research in diverse statistical populations, educational levels, and geographical regions would allow for comparisons of the obtained results across different groups.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by ethics committee of Islamic Azad University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors contributed to the study conception and design, material preparation, data collection and analysis and contributed to the article and approved the submitted version.

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