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Effect of Gagne's Learning Hierarchy on Cognitive and Metacognitive Skills of High School Students

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ABSTRACT

The purpose of the present study was to investigate the effect of Gagne's Learning Hierarchy on the cognitive and metacognitive skills of junior high school female students in Kerman. The research method was quasi-experimental with a pre-test/post-test and a control group. The statistical population of the research included all the junior high school female students of Kerman (N=1125) in the academic year of 2022-2023. From among these students, two classes of 20 students were randomly selected as the experimental and control groups. The Gagne's Learning Hierarchy package was implemented in the experimental group and both groups responded to Rastegar Metacognitive Strategies Questionnaire (2006) and Karami Cognitive Strategies Questionnaire (2005) in the pre-test and post-test stages. The obtained data were analyzed using univariate covariance with SPSS 20 software. The findings of the research showed that there was a significant difference between the cognitive and metacognitive skills of the experimental and the control groups and the cognitive and metacognitive skills of the experimental group improved compared to those of the control group. These results showed that learning English can improve students' recognition of concepts, processing, learning, and self-control.

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Introduction

One of the areas which is of great importance and causes the academic success of students is students' cognitive skills and metacognition (Javidan et al., 2018). Cognitive and metacognitive skills help students learn and transfer information from working memory to long-term memory (Yousefvand & Alavi, 2018). Moreover, cognitive strategies are behaviors and thoughts that affect the process of storing and retrieving information more effectively in memory (Saeedzadeh et al., 2018). These strategies help a person prepare new information to combine with previously learned information and store it in the long-term memory (Sherkat Naderi & Latifi, 2020). Since cognition refers to the processes by which people learn, think, and remember, any strategy that the learner uses for this purpose is called a cognitive strategy. Therefore, cognitive strategies are learning tools including "semantic expansion", "repetition or mental review" and "organization". In other words, the main action of a cognitive strategy is to help a person achieve the goal of a cognitive action (Panaoura & Philippou, 2007).

Cognitive ability is the ability to process and recall knowledge that helps students learn things and create knowledge in learning. If students have sufficient cognitive ability, they are more successful in learning (Rajaee Pitenoee et al., 2017). Those who do not increase and use their cognitive skills are likely to have problems with life tasks and activities (Hasbullaha & Basuk, 2018). Therefore, students should increase their cognitive ability; otherwise, they will face many problems (Jafari Dehnudasht, 2021). Also, cognitive ability is a process in the brain that helps students learn and improve themselves. If students have low cognitive ability, they are likely to learn poorly but if they have high cognitive abilities, they are more successful in academic performance (Abdolhosseini et al., 2011).

Metacognitive skills play an important role in a wide range of activities, including verbal information exchange, comprehension, reading, writing, attention, memory, problem-solving, learning, and self-control (Abassi et al., 2021). This helps to understand that metacognitive skills are known to be good predictors of academic success, even better than intelligence itself (Nelson & Marulis, 2017). Therefore, the level of metacognitive skills and students' use of them are the distinguishing variables between successful and unsuccessful students (Mari & Saka, 2018). Students who strategically use their metacognitive skills learn more and with less effort than students who do not use them (Sadeghi & Mohteshami, 2010). They recognize and solve problems more easily and discover the best ways to strengthen their learning and transfer it to other fields (Saadipour et al., 2018). This also makes them more engaged in learning and more motivated to learn in addition to providing more self-efficacy (Chatzipanteli et al., 2014).

Supporting the development of metacognition is a powerful way to promote college success for students who have strong metacognitive skills (Alborzi et al., 2022). They are in a position to learn more and perform better than their peers who are still developing their metacognition (Farrokhzadian et al., 2019). Students with well-developed metacognition can identify concepts they understand and choose appropriate strategies to learn those concepts (Pourhossein et al., 2021). They know how to implement the strategies they have chosen and generally execute their study plans. They can evaluate their strategies and adjust their plans based on the results. Metacognition allows students to be more expert in their thinking and have a more effective and efficient learning (Marcou & Philippou, 2005).

The concept of learning is one of the educational events that support the cooperative learning environment, and the research findings clearly show that cooperative learning must also be compatible with the learning hierarchy (Salehi & Ghanbari, 2020). In addition, problem-solving requires the use of prediction and analysis of facts and principles to identify cause-and-effect relationships between physical phenomena in the environment (Ines et al., 2023). Robert Gagne's educational theory has provided many valuable ideas to educational designers, educators, and teachers. Gagne conceived of learning as a change in human talent or ability. Gagne also argued that change can be maintained and should not be attributed solely to the growth process (Gagne, 1985, cited in Najafi Zand, 1994). Curriculum planners can apply this concept when examining the nature, depth, and breadth of linear coverage of programming materials such as those in the mathematics curriculum (Wei-Ling et al., 2020). In the hierarchy proposed by Gagne, problem-solving is the highest level of learning because it requires mastery of the next lower level. Problem-solving type of learning requires the application of principles and facts to explain and solve new phenomena or predict the consequences of known conditions (Devi, 2016). Gagne's learning theories have made a lasting impact on the field of education, especially in terms of curriculum design. Gagne's main theories include the classification of learning outcomes, learning conditions, and his educational event (Wei-Ling et al., 2020).

In addition to improving the understanding of learning hierarchy and hierarchical analysis,

Gagne introduced Mehmei's concept model: learners gradually acquire prerequisite skills before they want to master higher or more complex levels (Ines et al., 2023).

Gagne's classification of learning outcomes is somewhat similar to Bloom's classification of cognitive, emotional, and psychomotor outcomes. Both Bloom and Gagne believed that it is very important to divide human learned abilities into categories or domains. Gagne classification includes five categories of learning outcomes: verbal information, thinking skills, cognitive strategies, attitudes, and movement skills, each of which leads to a different class of human performance (Jadidi et al., 2019).

The rationale behind choosing the topic of this research was that the general expectation of society from schools is to provide the best education for the future generation and this is actually an obligation that lies on the school as well. Thus, in an organization that is considered to be the center of skills and expertise in education, emphasis should be placed on inner strength and potential capabilities such as cognitive and metacognitive skills that bring responsibility and pursue common interests. Therefore, the purpose of the research was to investigate the effect of learning Gagne on the cognitive and metacognitive skills of junior high school female students in Kerman.

Method

Design

In this research, a quasi-experimental method and a pre-test-post-test design with a control group were used.

Participants

To test the hypotheses of the research, two classes of 20 students were randomly selected from the junior high school female students of Kerman (N=1125) in the academic year of 2022-2023, and one was randomly selected as the experimental group and the other as the control group.

Instruments

Metacognitive strategies

To measure metacognitive skills, 13 questions of the metacognitive strategies subscale, Pintrich learning, and motivational strategies questionnaire were used. It should be noted that this questionnaire was used in the country by Fouladcheng (2013) and has appropriate psyschometric features. The reliability of this subscale in the present study was .85 using Cronbach's alpha method.

Cognitive strategies

The questionnaire on learning and study strategies was prepared by Karami (2005). To prepare this questionnaire, first various sentences related to the study and learning methods was collected based on theoretical studies and previously published questionnaires inside and outside the country. After removing duplicate questions (questions with similar content but with different words), the number of questions was reduced to 28, and each of them was assigned to cognitive sub-strategies. After collecting the questionnaire and entering the data into the SPSS software, Cronbach's alpha coefficient of cognitive was 0.80, and metacognitive was 0.85.

Procedure

To conduct the research, a briefing session was first held for the parents so that their children could participate in the research with the written consent of the parents. Then, before applying the pre-test, the student's cognitive and metacognitive skills were measured. Then, the Gagne learning levels intervention program was implemented (for three weeks and every week in three one-hour sessions in the classroom environment). No extra learning was applied to the control group. After the intervention of Gagne's learning levels, both groups were measured in cognitive and metacognitive skills in the post-test. The schedule of Gagne learning sessions is given in the following Table.

Table 1.
Description of Measures of Gagne's Learning Levels

Education levels	The proceedings
Drawing attention	You can attract the audience's attention by means of stimuli such as increasing the tone of the voice or gesture, showing a short clip related to the subject, or by using any device that makes people expect the lesson to begin.
Informing the learner of the goal (expectation):	You can explain to the group what they will learn at the end of this course and what benefits this learning will have for them and the organization.
Stimulating the recall of previous learning	Review the training programs you have already done for your team and apply them to the current training as well. Also, ask the group if they have previous experience in the

Education levels	The proceedings
	teaching topic. If they had problems in learning the previous topics, try to solve them in this course. Also, make connections between previously learned topics and current topics being taught.
Providing educational materials and stimuli	Organize information logically and in a simple way that fits the understanding of the audience. Try to use a variety of different tools and styles for people to learn, because they have different learning styles. (Tools such as visual communication, verbal guidance and active learning.
Guiding learning	The use of examples, case studies, figures, storytelling and analogies helps the team to learn effectively.
Test and performance recalling	Ask them to apply this learning. (Role-playing exercises can be helpful at this stage.) If you have taught them new information, test their learning by asking them questions.
Providing feedback	By providing feedback and tips, you inform them of their own mistakes so that they can fix these mistakes.
Evaluating performance	Tests, short questionnaires or even short writings are a good way to measure the team's knowledge in learning.
Enhancing learning and transfer	Repetition is the best way to ensure that information is learned and used effectively.

The data were analyzed using SPSS 20 software in two descriptive and inferential sections. In the descriptive part, statistical indices of variance, standard deviation, and mean were used, and in the inferential part, the covariance analysis method was used to measure cognitive and metacognitive strategies.

Findings

The average and standard deviation of the scores of the participants are presented separately for the experimental and control groups in Table 2.

Table 2.
The Average and Standard Deviation of the Scores of the Research Subjects in Cognitive and Metacognitive Skills by Groups

	Group	Number	Average	Standard Deviation
Cognitive skills pre-test	Experiment	20	70.45	6.83
	Control	20	70.90	6.24
Cognitive skills post-test	Experiment	20	112.05	6.36
	Control	20	69.65	8.20
Metacognitive skill pre-test	Experiment	20	31.39	3.72
	Control	20	32.35	3.39
Metacognitive skill post-test	Experiment	20	79.65	6.13
	Control	20	34.07	5.58

Normality of the dependent variable and covariance variable: To check the assumption of normality of the dependent variable and covariance variable, the Shapiro-Wilk test was used, the results of which are presented in Table 3.

Table 3.
Shapiro-Wilk test Results

Test steps	Shapiro-Wilk Test	DF	Sig
Cognitive skills pre-test	0.33	20	0.75
Cognitive skills post-test	0.66	20	0.24
Metacognitive skill pre-test	0.54	20	0.32
Metacognitive skill post-test	0.50	20	0.40

The results of Table 3 indicate that the scores in the pre-test and post-test are normal because the statistics of the two groups in each stage are more than 0.05. The results of Table 4 show the homogeneity of variances error in pre-test and post-test.

Table 4.
The Results of Levin's Test to Check the Homogeneity of Variance Error

Test steps	F	Df1	Df2	Sig
Cognitive skills pre-test	0.26	1	18	0.61
Cognitive skills post-test	0.60	1	18	0.38
Metacognitive skill pre-test	0.17	1	18	0.68
Metacognitive skill post-test	0.45	1	18	0.50

Table 5 shows the equality test of the slope of the regression line in the research variables, that is, the slope of the regression line is not different for the experimental conditions.

Table 5.
Equality Test of Regression Line Slope

Variables	sum of squares	Df	F	Sig
Cognitive	763.86	1	1.54	0.22
Metacognitive	174.58	1	0.50	0.84

Analysis of the Research hypotheses
The first hypothesis: learning Gagne affects students' cognitive skills.

Table 6.
Results of Univariate Analysis of Covariance for Cognitive Skills

Sources Change	Sum Of Squares	Df	Mean Square	F	Sig	Eta Squared
pre-test	764.21	1	58.78	1.12	380.38	0.37
main effect (treatment)	16198.04	1	16198.04	311.19	0.000	0.92
residual error	1301.28	37	52.05			

As can be seen in the above table, there is a significant difference between the cognitive skills scores of the experimental and the control groups' cognitive skills (significance level less than 0.05). Learning Gagne has an effect on students' cognitive skills with an effect size of (0.92).

The second hypothesis: learning Gagne affects students' metacognitive skills.

Table 7.
Results of Univariate Analysis of Covariance for Metacognitive Skills

Sources Change	Sum Of Squares	Df	Mean Square	F	Sig	Eta Squared
pre-test	221.25	1	24.58	0.65	0.74	0.16
main effect (treatment)	19197.33	1	19197.33	512.87	0.000	0.94
residual error	1085.49	37	37.43			

The results show that in the post-test, there is a significant difference between the metacognitive skills scores of the experimental and control groups (significance level less than 0.05). Thus, it can be claimed that learning Gagne has an effect on students' metacognitive skills with an effect size of (0.94).

Discussion

The purpose of the present study was to investigate the effect of learning Gagne on the cognitive and metacognitive skills of the junior high school female students of Kerman. The findings of the first hypothesis showed that learning Gangne has been effective in improving the cognitive skills of the participants. The results of the present research are in line with the

findings of Jadidi et al. (2019), Dupeyrat and Marine (2005), Rastegar (2015), as well as Sherkat Naderi and Latifi (2020). To explain these results, it can be stated that cognitive learning activities such as stimulus identification, response generation, process compliance, use of terms, discrimination, idea generation, law application, and problem-solving are performed in order in the Ganieh learning hierarchy. The main purpose of this hierarchy is to show what needs to be done before moving on to the next level of training. With the help of these steps, learners learn how to pay attention; how to study and organize a subject and how to analyze, combine, arrange and remember. All these methods lead to the development of subtle abilities involved in learning to think; It is created, discovered and remembered, and based on this, the cognitive skills of the learners are improved.

Also, in Gagne's method, by providing the opportunity to practice creating new solutions to existing problems and to learn attitudes, the learner is exposed to an authentic model or persuasive arguments, and in this way, it helps improve the cognitive skills of learners. On the other hand, to improve cognitive processes that include the ability to learn the relationships between concepts and apply these relationships in different situations, the situations that have not been encountered before are used. This method forms the basis for learning general rules and procedures. In this method, to learn a rule, two or more concepts are linked together. By learning the concepts and rules of the components by the student, the teacher can use oral teaching alone to guide the student to put the rules together (Worokwu, 2022).

Also, the findings showed that learning Gagne has been effective in improving students' metacognitive skills. The results of the present study are in line with the findings of Jadidi et al. (2019), Fouladcheng et al. (2013), and Sherkat Naderi and Latifi (2020). One of the goals of learning about metacognitive skills is that the student learns how to take control of his/her learning goals and evaluate their progress toward achieving them. Because by improving metacognitive skills, it allows students to quickly identify what knowledge they lack or is incorrect. Metacognitive skills contribute to the learner's ability to transfer knowledge to solve new problems. In Gagne's method, to improve students' metacognitive skills, they are continuously asked to question their level of knowledge and improve their understanding.

Conclusions

Because lifelong learning is an ideal goal in education, the Gagne method can help by improving metacognitive skills (Becker, 2014). Studies by Kalste (2011), Goldbrick and Bush (2003) and Azovi (2011) have shown that there is a significant correlation between metacognition and problem-solving, and that metacognition makes learners organize their mental processes more actively. According to Tobias and Orson (2000), the basic component in the problem-solving process, as the highest level of the cognitive process in Gagne's view, is metacognition, and metacognitive skills guarantee awareness and control in the problem-solving process. In addition, they also state that metacognition relates cognitive behaviors to non-cognitive factors present at each stage of problem-solving. Students' self-questioning and monitoring of their behaviors in the problem-solving process are considered metacognitive skills. Also, knowledge about preferred strategies and problem-solving steps in the problem-solving process is considered a metacognitive skill in the Ganieh learning process (Sengul & Katranci, 2015).

In general, Gagne's educational design model is based on the information processing model of mental events that occur when different stimuli are presented to learners and focus on learning outcomes and how to arrange specific educational events to achieve learning outcomes. Applying Ganiye's nine-step model is an excellent way to ensure an effective and systematic learning program because it gives structure to the lesson plan and gives a holistic view of education (Worokwu, 2022).

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Conflicts of Interest

The authors of this article declare that there was no conflicts of interest.

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