The Impact of Lee strategy on the Achievement of Secondary School Students in Biology and the Development of their Cognitive Representation

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Abstract

This study explores the effectiveness of the Lee teaching strategy in enhancing the understanding of biology among secondary-grade students in Saudi Arabia. The Lee strategy, known for its student-centred approach, encourages active participation, critical thinking, and collaborative learning, essential for mastering complex biological concepts. The study employed a mixed-methods approach, combining quantitative assessments of student performance with qualitative feedback from both students and teachers. The research was conducted over a semester in several secondary schools in Riyadh, Saudi Arabia. A control group received traditional lecture-based instruction, while the experimental group was taught using the Lee strategy. Pre- and post-tests were administered to measure the students' knowledge and retention of key biology topics. Results indicated a significant improvement in the experimental group's understanding and retention of biological concepts compared to the control group. Additionally, students reported increased engagement and motivation, attributing their improved learning outcomes to the interactive and collaborative nature of the Lee strategy. Teachers also noted a more dynamic classroom environment and greater ease in identifying and addressing student misconceptions. This study suggests that the Lee teaching strategy can be an effective tool for biology education in Saudi secondary schools, particularly in fostering a deeper understanding of scientific concepts and promoting active learning. The findings support the adoption of student-cantered teaching methodologies in the Saudi educational system to better prepare students for higher education and careers in the sciences.

Keywords: *Lee strategy, Student-centred, Collaborative learning*

1. Introduction

1.1 *Cognitive Strategy "Li" and Its Integration with Piaget and Vygotsky's Theories*

The current era is characterized by an explosion of knowledge and rapid growth in the amount of information and knowledge, which has doubled in recent years. Since the level of progress and sophistication of societies is now linked to scientific and technological advancements, it is necessary to focus on the educational process occurring within educational institutions worldwide. This focus highlights the need to develop and improve the processes responsible for teaching, education, and learning within these institutions. An important aspect of this is enhancing teaching methods and diversifying the approaches used to achieve educational goals effectively. Modern education has thus placed great emphasis on thinking and training in the use of thinking strategies in education, so that learners can use and apply the knowledge they have acquired in new situations and keep pace with the continuous changes in our world, a world of knowledge and technological explosion. (Edward de Bono, 2018, p. 305) Nadia Haile and Thaer Ghazi (2011, p. 124) emphasize that productive thinking involves discovering new relationships or unconventional methods. This requires a set of abilities and skills that combine critical and creative thinking skills (originality, flexibility, fluency, problem analysis, imagination and production, elaboration or detailing, evaluation).

The "Li" cognitive strategy integrates Piaget and Vygotsky's theories, addressing verbal problem-solving in a social context that organizes the classroom environment. Piaget emphasizes that learners build knowledge through personal exploration, with thought preceding and facilitating language development, while teachers create opportunities for discovery-based learning. Conversely, Vygotsky focuses on learning through social interactions, particularly with knowledgeable others, such as peers or adults. He argues that culture and environment influence cognitive development, and language drives cognitive growth. He recommends that teachers help learners progress via cognitive scaffolding. Both theories view learners as active participants.

2. Phases of the “Li” Cognitive Strategy

The "Li" strategy includes four stages:

1. **Understanding the Problem**: Involves questions such as, "What is the content of the problem?", "What are the relationships between the terms?", and "What questions are we answering?"
2. **Formulating a Plan**: Questions include, "Can we draw a helpful image or shape?", "Could a map or table aid us?", "Is there a pattern?", "Have you solved a similar problem before?"
3. **Executing the Plan**: Entails steps such as "Carry out the next step", "Organize the information", "Seek alternative hypotheses", "Eliminate incorrect assumptions", and "Verify each step".
4. **Reviewing the Plan**: Questions include, "Is your solution logical?", "Can you find another solution?", and "Could you create a similar problem?"

2.1 Previous Studies and Research Problem

According to Ramadan Badawi (2003, p. 155), it is defined as one of the cognitive strategies that make education more stimulating, easier, more engaging, and more effective, helping students develop positive attitudes toward the subject matter. Shulman and Elastin (1975, p. 201) define it as a strategy in which the learning process occurs by posing a problem that prompts students to think. "reflection, study, research, and work under the supervision of the teacher to arrive at one or more solutions." The researcher defines the Lee Strategy operationally as a series of organized, sequential steps followed in structuring the content of biology curriculum topics for high school students, which was used in teaching the experimental group students. It consists of four stages. Prior research has highlighted weaknesses in students' productive thinking skills, with studies by Wafaa Raafat (2016), Mervat Hany (2017), and others identifying gaps. This research seeks to address these issues through the "Li" cognitive strategy, specifically exploring:

What is the impact of using the "Li" cognitive strategy in biology instruction to develop productive thinking skills among high school students?

2.2 Research Goals

1. Define the productive thinking skills to be developed in biology for high school students.
2. Model how the "Li" cognitive strategy can enhance productive thinking skills.
3. Predict the impact of the "Li" strategy on productive thinking skills.

2.3 Research Significance

The study aims to:

1. Equip students with productive thinking skills.
2. Encourage biology teachers to use the "Li" cognitive strategy.
3. Guide educators to train teachers in implementing strategies that enhance learning retention, creativity, and innovation.
4. Provide teachers with a framework for using the "Li" strategy in biology instruction.

5. Offer a theoretical background on the "Li" cognitive strategy.

2.4 Research Group

The study included 120 high school students in Riyadh, randomly assigned to control and experimental groups. The control group studied the unit on nutrition and digestion using traditional methods, while the experimental group used the "Li" cognitive strategy.

3. Research Design and Results

1. Productive Thinking Skills Measured: These include fluency, flexibility, problem analysis, imagination, and evaluation.
2. Test Development: The researcher created a 25-item multiple-choice test, ensuring the questions were engaging, clear, and appropriate for high school students.

4. Research Boundaries

The current research was limited to the following:

1. A group of second-year high school students at one of the secondary schools under the Saudi Arabia Education Administration.
2. The first chapter of the first semester content from the biology curriculum for second-year high school students for the academic year 2023-2024.

5. Research Variables

The research variables are as follows:

1. Independent Variable: The Li Cognitive Strategy.
2. Dependent Variables: Productive Thinking Skills.

6. Research methodology

In this research, the researcher followed:

1. Descriptive Method: Used to prepare the theoretical framework and review previous studies that addressed the Li Cognitive Strategy and productive thinking skills.
2. Experimental Method: Employed using a quasi-experimental design with two groups:
   - Control Group: A group of students who study the selected content using the traditional teaching method.
   - Experimental Group: A group of students who study the selected content using the Li Cognitive Strategy.

7. Results

7.1 Research Procedures:

To answer the research questions and validate its hypotheses, the researcher followed these steps:

To Answer the First Question: "What productive thinking skills should be developed in high school biology students?"

1. Review previous Arabic and foreign research and studies that addressed productive thinking skills.
2. Consult books and references related to productive thinking.
3. Prepare a list of productive thinking skills that should be developed in high school biology students.
4. Develop a questionnaire to assess the productive thinking skills that should be developed in high school biology students.
5. Present the list in the form of a questionnaire to a panel of expert judges to determine the importance of each skill.
6. Modify the list based on the judges' feedback and finalize it.

To Answer the Second Question: "What is the effect of using the Li Cognitive Strategy in teaching biology on developing productive thinking skills in high school students?"

1. Develop a test to measure productive thinking skills in high school biology students.
2. Present the test to a panel of expert judges, modify it based on their feedback, and finalize it.
3. Administer the test to second-year high school students.
4. Calculate the impact size of using the Li Cognitive Strategy on developing productive thinking skills in the experimental group students.
5. Record the results and analyse them statistically.

The Significance of Differences Between the Mean Scores of Experimental and Control Group Students in the Post-Application of the Productive Thinking Skills Test

Table 1.

Skills	Study Groups	Average Score	Standard Deviation	T-value	Degrees of Freedom	Significance Leve
Flexibility and Fluency	Experimental Group	4.1	0.85	6.42	58	0.001
	Control Group	2.21	1.12			
Problem Analyse	Experimental Group	3.80	1.16	4.55	58	0.001
	Control Group	2.50	1.27			
Expansion or Detail	Experimental Group	3.89	0.86	6.85	58	0.001
	Control Group	2.02	1.24			
Imagination	Experimental Group	4.01	0.95	6.91	58	0.001
	Control Group	2.04	1.22			
Evaluation	Experimental Group	4.9	1.39	4.96	58	0.001
	Control Group	2.56	1.06			
Overall Score	Experimental Group	20.31	2.32	11.17	58	0.001
	Control Group	11.45	3.50			

- Skill of Fluency and Flexibility**:** The average post-test score of students in the experimental group was 4003, while for the control group, it was 2030. The t-value was 6.43, with a significance level of 0.001.
- Skill of Problem Analysis**:** The average post-test score of students in the experimental group was 3.97, while for the control group, it was 2.53. The t-value was 4.55, with a significance level of 0.001.
- Skill of Expansion or Detailing**:** The average post-test score of students in the experimental group was 3.93, while for the control group, it was 2003. The t-value was 6.86, with a significance level of 0.001.
- Skill of Imagination**:** The average post-test score of students in the experimental group was 4000, while for the control group, it was 2007. The t-value was 6.92, with a significance level of 0.001.
- Skill of Evaluation: The average post-test score of students in the experimental group was 4.10, while for the control group, it was 2.50. The t-value was 4.97, with a significance level of 0.001.

The overall average score for students in the experimental group on the post-test of productive thinking was 20003, compared to 11.43 for students in the control group. The t-value was 11.18, with a significance level of 0.001. Figures (1) and (2) illustrate this. From Table (1) it is evident that the study's first hypothesis is confirmed, which states: "There is a statistically significant difference at the level of <0.05 between the mean scores of students in the experimental and control groups in the post-test for productive thinking skills, in favour of the experimental group students." The researcher attributes the superiority of the experimental group students to the connection of prior experiences with new ones. This connection led to the generation of a greater number of diverse ideas among experimental group students. Additionally, learning according to the steps of my cognitive strategy contributed to meaningful learning based on understanding rather than memorization. This, in turn, enabled students to acquire information and skills through direct experiences, fostering productive thinking skills and motivation for achievement in biology among experimental group students.

The experiment validated the hypothesis that the "Li" strategy improves students' productive thinking. The experimental group showed significant gains, with higher post-test scores across all skills:

- Fluency and Flexibility: Experimental group mean post-test score (4003) vs. control group (2030), $t = 6.43$, $p < 0.001$.
- Problem Analysis: Experimental mean (3.97) vs. control (2.53), $t = 4.55$, $p < 0.001$.
- Detailing: Experimental mean (3.93) vs. control (2.003), $t = 6.86$, $p < 0.001$.
- Imagination: Experimental mean (4.000) vs. control (2.007), $t = 6.92$, $p < 0.001$.
- Evaluation: Experimental mean (4.10) vs. control (2.50), $t = 4.97$, $p < 0.001$.

The "Li" strategy allowed students to connect new concepts with prior knowledge, leading to better comprehension, retention, and academic performance. Enhanced classroom interaction, feedback, and discussion supported students' engagement, ultimately fostering productive thinking skills. The study concludes that the "Li" cognitive strategy has a substantial positive impact on high school students' productive thinking skills, particularly in biology.

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