

THE EFFECTIVENESS OF AN INSTRUCTIONAL PROGRAM BASED ON DEEP PROCESSING THEORY IN FIFTH SCIENTIFIC GRADE STUDENTS' ACQUISITION AND RETENTION OF CIRCULAR AND ROTATIONAL MOTION CONCEPTS

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Abstract

This research aims to design and implement an educational programme based on Deep Processing Theory to enhance the acquisition and retention of circular and rotational motion concepts among fifth-grade scientific stream students. A quasi-experimental design was employed (comprising two groups: experimental and control), utilising measurement tools that included a conceptual test (pre-test and post-test) and a retention test administered after one month. The results demonstrated significant differences in favour of the experimental group students in both the post-test and conceptual retention.

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Keywords: Deep Processing Strategy, Meaningful Learning, Physics Concepts, Concept Retention, Secondary Education.

Research Problem and Importance:

The world is witnessing significant technological development and a renaissance across various fields, necessitating full preparation for such progress. In this era of the cognitive revolution, the teacher is no longer the sole source of knowledge; information has become multifaceted, and the methods of accessing it have diversified. Consequently, the teacher's role has transitioned into that of a mediator between learners and sources of knowledge, acting more as a guide and facilitator than a mere lecturer.

Since the learner is the pivot of the educational process, focus must be placed on developing their capacities for retention and recall through a deep understanding of scientific material. This is particularly vital as the target group of the current

research—fifth-grade scientific stream students—is transitioning to university, where most scientific specializations involve the study of physics.

Physics is considered a vital scientific subject that forms an essential knowledge base for all scientific, engineering, and medical specializations (Al-Zuhairi, 2020), as it provides a comprehensive understanding of natural phenomena and the laws of nature. Nevertheless, physics education faces immense difficulties due to its reputation as a challenging subject dealing with abstract concepts and complex scientific problems. This necessitates the adoption of educational strategies that enable students to interact with the material more deeply and effectively (Al-Husseini, 2021).

The researcher concurs with Al-Bawi and Karim (2022) that positioning students at the centre of the educational process and encouraging them to participate in acquiring physical knowledge from diverse sources provides them with rich and engaging educational experiences. This fosters a sense of enjoyment and wards off feelings of boredom and frustration (Al-Bawi and Karim, 2022, p. 98), thereby making learning easier and more retentive.

Among the findings of the study by Wilcox et al. (2020) regarding conceptual retention following an interactive educational intervention, a significant stability in understanding was demonstrated, even after periods extending to 15 months. Here, the importance of deep processing strategies in education emerges. These strategies are based on understanding concepts, linking them to students' prior experiences, critical thinking, and the use of educational activities that stimulate profound thought and analysis (Al-Mahdi, 2018). Such strategies assist in enhancing the recall and retention of information over long periods, facilitating its activation and application in various new contexts. Students can be trained in retention and recall by applying techniques such as summarisation, mind mapping, group discussion, and problem analysis to enhance deep information processing and increase students' ability to retrieve knowledge effectively (Al-Sahli, 2019). Thus, it appears that integrating deep processing strategies into physics teaching significantly contributes to improving student achievement and fostering sustainable, long-lasting deep information processing.

The significance of this research is highlighted by the following:

- It provides a cognitive theoretical framework (for deep processing) in physics education, rather than relying solely on traditional instruction, simulations, or other strategies.

- It presents an educational programme design for instructional strategies that promote deep thinking and frequent retrieval, leading to genuine sustainable learning.
- It offers educational tools—developed, validated, and piloted—based on deep cognitive foundations to measure the acquisition and retention of concepts.

Accordingly, the research problem and its significance can be expressed through the following question: Does an educational programme based on deep processing achieve better acquisition and retention of circular and rotational motion concepts compared to traditional teaching methods?

❖ Research Objectives

The current research aims to:

1. Design an educational programme based on the deep processing of information.
2. Measure the impact of an educational programme based on deep processing theories on the acquisition of circular and rotational motion concepts compared to the traditional method.
3. Measure the impact of the educational programme on students' retention of these concepts.

❖ Hypotheses

1. There is no statistically significant difference at the significance level of (0.05) between the mean scores of the two groups (experimental and control) in the pre-test for circular and rotational motion.
2. There is no statistically significant difference at the significance level of (0.05) between the mean scores of the two groups (experimental and control) in the post-test for circular and rotational motion.
3. There is no statistically significant difference at the significance level of (0.05) between the mean scores of the two groups (experimental and control) in the retention test for circular and rotational motion.

❖ Delimitations

- Scope: Fifth-grade scientific stream students.
- Subject Scope: Chapter Seven of the Physics textbook for the fifth scientific grade, prescribed for the academic year 2023-2024.

- Temporal Scope: The second semester of the academic year 2023-2024.
- Spatial Scope: Secondary and preparatory schools in Fallujah District, Al-Anbar Governorate.

❖ Definitions

1. Educational Programme:

- It is a set of organised experiences and activities provided to learners to achieve specific educational goals within a certain period (Sabah, 2015).
- It is "a plan comprising objectives, content, instructional strategies, and evaluation methods, prepared to achieve specific educational outcomes for a particular group of learners" (Mahdi, 2018).
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2. Deep Processing:

- Zaitoun (2003) defines it as "a cognitive style in which new information is linked to prior knowledge, analysed, and transformed into personal meaning, leading to more established learning and retention of information."
- Abdul Razzaq (2019) defines it as "a set of educational strategies that enable the learner to achieve an integrated understanding of information through analysis, comparison, and interpretation, rather than rote memorisation, thereby achieving long-term learning."
- It is "the active mental interaction with information, whereby the learner reorganises, reformulates, and understands it within a broader context, using higher-order thinking skills such as interpretation, inference, and correlation" (Al-Akili, 2020).

3. Acquisition:

- It is the process through which new information is integrated into the learner's cognitive structure, understood, and assimilated in a way that enables its subsequent use in similar educational or life situations. Acquisition is considered an indicator of effective learning and the success of educational processes (Adas, 2004).

- It is "the initial result of learning, referring to the student's ability to understand new concepts or skills immediately after they are presented. It is typically measured by achievement tests conducted directly after the instructional situation" (Mahjoub, 2011).

4. Retention

- ❖ "The learner's ability to retain the information and knowledge they have learned for a specific period after the completion of the learning process, and to retrieve it when needed in new educational or life situations" (Adas, 2004).
- ❖ "The retention of learned information in the long-term memory for a later period; it is measured through tests administered after a period of time following the conclusion of learning to determine the extent to which concepts or skills have been consolidated" (Fadel, 2019).

❖ Theoretical Framework.

First: First: Deep Processing Theory

This theory is considered one of the most prominent theoretical foundations of deep processing. Craik and Lockhart argue that the persistence of information in memory depends on the depth of processing rather than repetition; the deeper the processing and the more it is associated with meaning, the greater the likelihood of its later recall.

Adas (2004) explains that this theory has contributed to understanding how information encoding processes occur within human memory. He states that "deep learning occurs when educational material is understood and linked to prior experience or meaningful life situations" (Adas, 2004, p. 165).

Key Characteristics of Deep Processing:

1. Linking with prior knowledge.
2. Analysis, interpretation, and understanding.
3. Utilising critical thinking and inference.
4. Personal meaning of the information.
5. Long-term retention of information.

Fadel (2019) clarified that students exposed to deep processing strategies demonstrate higher levels of retention and understanding compared to students who learn via traditional methods (Fadel, 2019, p. 152).

Teaching Strategies Based on Deep Processing

Deep processing strategies include the following:

- Deep Questions: (Cause, effect, and analysis).
- Concept Maps.
- Brainstorming and Group Analysis.
- Problem Solving.
- Discussion and Interpretation.

Al-Akili (2020) indicated that these strategies develop deep understanding and increase students' ability to acquire and retain concepts (Al-Akili, 2020, p. 135).

Importance of Deep Processing in Learning

Educational studies indicate that deep processing:

- Increases academic achievement.
- Enhances long-term retention of information.
- Develops higher-order thinking skills.
- Assists in the transfer of learning to new situations.

❖ Previous Studies

1- Studies on deep treatments

Author and Year	Study Title	Key Findings
Karim, Zohoor Mohammed (2016)	The impact of an educational model based on deep cognitive processing on achievement and the development of attitudes towards Physics.	A clear improvement in achievement and attitudes towards Physics.
Fadel, Khalil Ibrahim (2019)	The impact of using cognitive strategies on the achievement and retention of physical concepts among fifth-grade scientific stream students.	Significant improvement in achievement and retention as a result of applying deep processing.
Ali, Hussein Salman (2017)	The impact of deep learning strategies on developing reflective thinking skills and achievement among preparatory stage students.	High effectiveness in developing reflective thinking and achievement.

2- Previous studies on acquisition

Author and Year	Study Title	Key Findings
Nasser, Abdullah Masoud Abdullah (2005)	The Effect of Teaching Physics Using Visual Illustrations on the Acquisition of Physical Concepts and the Development of Thinking and Problem-Solving Skills.	Improved the acquisition of physical concepts, reasoning, and problem-solving.
Alimat, Ayman Mohamed Khalaf (2018)	The Effect of Using the Blended Learning Model on the Motivation to Learn and the Acquisition of Scientific Concepts among Ninth-Grade Students.	Improved motivation and conceptual acquisition in the experimental group.
Al-Harishawi, Qusay Aber (2019)	The Effectiveness of an Educational Programme According to Wheatley and Ableton's Model in Acquiring Physical Concepts among Fourth-Grade Scientific Students.	Facilitated the acquisition of physical concepts.
Mohsen, Waheed Ghafouri (2024)	The Effect of Smith's Strategy on the Acquisition of Scientific Concepts among Fourth-Grade Students of Physics.	The students of the experimental group excelled in the acquisition of concepts and lateral thinking.

3. Previous studies on retention in physics

Author and Year	Study Title	Key Findings
Abu Aal, Mahdi Mohammed Jawad (2009)	The effect of using visual puzzles and advanced organisers on achievement and information retention among second-grade intermediate students in Physics.	The results showed that the use of visual puzzles and advanced organisers increases the retention of physical information among students.
Al-Zubaidi, Fatima Abid Shayoul (2014)	The effect of using the Thalen model on the acquisition of physical concepts and the development of scientific thinking among second-grade intermediate female students.	The research results showed that the use of the scientific stations strategy helped raise the level of retention compared to the traditional method.
Mahmoud, Faten Sattar (2015)	The effectiveness of the Self-Correction Schedule strategy (K – W – L – H) in the acquisition and retention of physical concepts among fourth-grade scientific female students.	The results indicated that the use of the strategy had a positive effect on both the acquisition and retention of physical concepts.
Mohammed, Hala Mahdi (2021)	The impact of an educational programme based on Cognitive Load Theory on the retention of scientific concepts among intermediate-stage female students.	The programme proved effective in enhancing the retention of concepts.

❖ Search Procedures

1. Research Population and Sample:

The research population was defined as all fifth-grade scientific stream students in public and private secondary schools within the Fallujah District of Al-Anbar Governorate for the academic year 2023-2024.

As for the research sample, Abu Ja'far al-Mansur Preparatory School for Boys was purposively selected due to the availability of multiple classes for the fifth scientific grade, as well as the cooperation of the school administration and the facilities provided to the researcher to conduct the study.

Section (C) was randomly selected to represent the experimental group, comprising (50) students, while Section (D) was selected as the control group, comprising (45) students.

2. Group Equivalence:

Despite the random selection of the research sample, the researcher deemed it necessary to ensure equivalence between the two research groups regarding variables believed to potentially influence the dependent variable, namely: (chronological age, previous achievement in Physics, and intelligence).

Data for chronological age and students' achievement in the mid-year examination were obtained from school records, as detailed in Table (1). Regarding the intelligence variable, data were collected following the administration of the Raven's Progressive Matrices test to the students of both groups.

After calculating the means and standard deviations, the t-test for two independent samples was employed to test the significance of the differences between the means for each equivalence variable. Table (1) demonstrates that the calculated t-value for each variable was lower than the tabular value. Thus, it can be concluded that the differences are non-significant at the significance level of (0.05) and (93) degrees of freedom, indicating the equivalence of the two groups across all variables.

Table (1) Equivalence Data

Group	Variable	Mean	Standard Deviation	Calculated (t) Value	Tabulated (t) Value	Degrees of Freedom	Statistical Significance
Experimental	Chronological age (months)	\$210.4\$	\$6.2\$	\$1.090\$	\$1.701\$	\$28\$	Non-significant at \$0.05\$
Control		\$208\$	\$5.9\$				
Experimental	Previous Physics Achievement	\$77.6\$	\$15.39\$	\$0.24\$	\$1.701\$	\$28\$	Non-significant
Control		\$76.4\$	\$12.33\$				
Experimental	Intelligence	\$17.1\$	\$5.9\$	\$0.266\$	\$1.701\$	\$28\$	Non-significant
Control		\$17.14\$	\$5.1\$				

2. Preparation of Research Requirements

Educational Programme Preparation

The educational programme was developed through the following stages:

- Identifying learner characteristics: This was achieved by administering the equivalence tests detailed in Table (1).
- Defining the scientific instructional material: The material was restricted to Chapter Seven of the Physics textbook for the fifth scientific grade, prescribed for the 2023-2024 academic year.
- Identifying primary and sub-concepts: Both core and secondary concepts related to circular and rotational motion within the specified textbook chapter were identified.
- Selecting teaching strategies: Strategies based on deep processing were chosen for their suitability to current school conditions and the students' academic level and chronological age. These included: Deep Questioning(cause, effect, analysis), Concept Mapping, Brainstorming and Group Analysis, and Problem-Solving.
- Designing educational activities: Instructional activities were designed based on the selected strategies and the curriculum content.
- Drafting lesson plans: Detailed instructional plans were written for the experimental group according to the chosen strategies, alongside an equal

number of plans for the control group, which studied the same material using the traditional method.

- Scheduling evaluation: Dates for assessment and the administration of tests were set for both groups.

Research Tool Preparation

The current research required the development of a test to measure the research sample's acquisition of physical concepts related to circular and rotational motion, conducted according to the following steps:

1. Twenty main and subordinate concepts related to circular and rotational motion were identified from Chapter Seven of the Physics textbook for the fifth scientific grade, prescribed for the academic year 2023-2024.
2. Validating the analysis: The list of concepts was presented to a number of Physics teachers to ensure analytical validity; unanimous agreement was reached (Appendix 1).
3. Drafting test items: Three objective items were prepared for each concept to measure Definition, Discrimination, and Application. Each item featured four multiple-choice options, resulting in a total of 60 items. One mark was awarded for a correct answer and zero for an incorrect answer. Scores were subsequently converted using proportionality to range from 0 to 100, with a mean of 50, to facilitate calculations and the presentation of results.
4. Face validity: To ensure face validity, the test was presented to a panel of referees specialising in Physics and its teaching methods (Appendix 2).
5. Reliability, timing, and clarity: The test was piloted on a reconnaissance sample of 75 students from the research population (excluding the main sample) selected from () High School. The pilot confirmed the clarity of the items, with an average completion time of 55 minutes. Using the Kuder-Richardson formula, the reliability coefficient was found to be , which is an acceptable rate.
6. Statistical analysis: Data from the pilot application were used to calculate difficulty coefficients, which ranged between (0.34-0.67) , and discrimination coefficients, which ranged between (0.54-0.35) . The effectiveness of the distractors (alternatives) was found to be negative for all items (Appendix 3).

All indicators demonstrate that the test is valid, reliable, and possesses acceptable levels of difficulty and discrimination, rendering it ready for implementation.

❖ Experiment Application

1. Preliminary Phase:

- Administration of the pre-test for the acquisition of physical concepts to both groups.
- Administration of the Raven's Progressive Matrices intelligence test.

2. Programme Execution Phase:

- Implementation of the educational programme for the experimental group.
- Instruction of the same concepts to the control group using the traditional method.

3. Concluding Phase:

- Administration of the post-test for the acquisition of physical concepts to both groups.
- Administration of the concept acquisition test to both groups after a period of one month to measure retention.

❖ Statistical Treatments

The data were processed using SPSS (Version 26), employing the following statistical methods:

- Independent Samples t-test: Used to test the significance of differences between the means of the two research groups.
- Cronbach's Alpha Formula: Utilised to measure the internal consistency and reliability of the test.
- Discrimination Coefficient Formula: Applied to objective items to measure the discrimination power of the items and the effectiveness of the distractors (alternatives).
- Difficulty Coefficient Formula: Used for objective items to measure the difficulty level of the test items.

❖ View and interpret the results:

The results of the experimental application will be presented and interpreted according to the research hypotheses as follows:

1- Testing the first hypothesis, which states that "there is no statistically significant difference at the significance level of (0.05) between the average scores of the two groups (experimental and control) in the pre-test for the acquisition of physical concepts."

After correcting the answer sheets of the research sample on the pre-test to acquire and organise physical concepts and calculating the arithmetic averages and standard deviations, the t-test for two independent samples was used, and the results were as in Table (2).

Group	Sample Size (n)	Arithmetic Mean	Standard Deviation	Calculated t-value	Tabulated t-value	Degree of Freedom	Statistical Significance (0.05)
Experimental	50	22.76	9.63	0.213	1.984	93	Non-significant
Control	45	22.33	9.82				

Table (2) shows that the means of the two groups are lower than the theoretical mean of the test. It also indicates that the calculated t-value is smaller than the tabulated t-value. Therefore, the first null hypothesis is accepted, meaning that the difference between the means of the two groups on the physical concepts acquisition test is not statistically significant, and there is no significant difference between them.

2- Testing the second hypothesis, which states that "there is no statistically significant difference at the significance level of (0.05) between the average scores of the two groups (experimental and control) in the post-test for the acquisition of physical concepts."

After correcting the answer sheets of the research sample for the post-test to measure the acquisition of physical concepts, organising them, and calculating the arithmetic means and standard deviations, the t-test for two independent samples was used. The results were as shown in Table (3).

Group	Number	Arithmetic Mean	Standard Deviation	Calculated t-value	Tabulated t-value	Degree of Freedom	Statistical Significance at 0.05
Experimental	50	80.02	12.8	3.425	1.984	93	Significant
Control	45	70.55	14.1				

It appears from Table (3) that the means of both groups are higher than the theoretical mean of the test, and the calculated t-value is greater than the tabulated t-value. Consequently, the second null hypothesis is rejected, indicating that the difference between the means of the two groups in the physical concept acquisition test is statistically significant, with a meaningful difference in favour of the experimental group.

These results are consistent with the findings of both (Karim, 2016 and Salman, 2017), which indicated that teaching strategies based on deep processing improve the science learning process. They also align with the results of studies by (Alimat, 2018; Al-Harishawi, 2019; Mohsen, 2024; and Nasser, 2025), which demonstrated that the use of modern instructional strategies helps improve the acquisition of physical concepts compared to the traditional method.

3- Testing the third hypothesis, which states that "there is no statistically significant difference at the significance level of (0.05) between the average scores of the two groups (experimental and control) in the physical concept retention test."

After correcting the answer sheets of the research sample for the physical concept acquisition test—following its second administration one month after the initial post-experiment application—and organising the data and calculating the arithmetic means and standard deviations, the t-test for two independent samples was employed. The results were as shown in Table (4).

Group	Sample Size (n)	Arithmetic Mean	Standard Deviation	Calculated t-value	Tabulated t-value	Degree of Freedom	Statistical Significance at 0.05
Experimental	50	72.22	14.9	4.33	1.984	93	Significant
Control	45	58.66	15.56				

Table (4) shows that the mean score for the experimental group in the retention test is (72.22), which is lower than the mean for the same group in the post-test, which was (80.02). This indicates that the amount of information loss constitutes a rate of (7.8%).

Furthermore, the mean score for the control group in the retention test is (58.66), which is lower than the mean for the same group in the post-test, which was (70.55). This indicates that the amount of information loss constitutes a rate of (11.88%).

It is also evident from Table (4) that the means of both groups are higher than the theoretical mean of the test. The calculated t-value is greater than the tabulated t-value. Consequently, the third null hypothesis is rejected, meaning that the difference between the means of the two groups in the physical concept retention test is statistically significant, and there is a meaningful difference between them in favour of the experimental group.

The use of the programme in teaching the experimental group enabled the students to retain the acquired physical concepts at a good level. While the traditional method also contributed to the students' retention of the acquired physical concepts, it was at a lower level.

The results of the current research are consistent with the findings of previous studies (Abu Aal, 2009; Al-Zubaidi, 2014; Mahmoud, 2015; Mohammed, 2021). These studies demonstrated that the use of modern strategies in teaching Physics and involving students in the educational process leads to an increase in the retention of information and concepts for a long period after learning has occurred.

❖ Conclusions

In light of the research results, the researcher concluded that the educational programme based on deep processing theory was effective in enabling the students of the experimental group to acquire and retain physical concepts to a high degree compared to the traditional teaching method used with the control group.

❖ Recommendations

The recommendations based on the results are as follows:

1. Adopting deep processing strategies in the teaching of physics.

2. Preparing training programmes for teachers on the use of deep processing strategies.
3. Incorporating deep processing strategies into the curricula of teaching methods in colleges of education.

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Section Two: Foreign References

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Appendix (1)

Main and Sub-concepts for Chapter Seven

No.	Concept	No.	Concept
1	Circular Motion	11	Real Weight
2	Angular Displacement	12	Apparent Weight
3	Angular Velocity	13	Rotational Motion
4	Linear Speed	14	Moment of Inertia
5	Angular Speed	15	Rotational Energy
6	Angular Acceleration	16	Combined Motion
7	Centripetal Force	17	Angular Momentum
8	Vanishing of Centripetal Force	18	Torque
9	Non-uniform Circular Motion	19	Work
10	Angular Acceleration	20	Rotational Power