# The Effectiveness of Teaching Method Based on the Components of Concept-Rich Instruction Approach in Students Achievement on Linear Algebra Course and Their Attitudes Towards Mathematics

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*The study aimed to investigate the effectiveness of a teaching strategy based on a Concept-Rich Instruction approach in the student's achievement in a linear algebra course and their attitudes towards mathematics. The study sample consisted of (112) male and female students divided into two groups. An experimental group of (55) male and female students taught using a teaching strategy based on Concept-Rich Instruction. A control group of (57) male and female students were taught traditionally. The study data were collected using a mathematical test and a questionnaire that measures students' attitudes towards mathematics. The study results showed statistically significant differences between the two study groups and in favor of the experimental group in the achievement test and the measure of attitudes towards mathematics. The study recommended using the Concept-Rich Instruction approach in teaching the linear algebra course to improve achievement, enhance students' attitudes towards mathematics, and invite students to use these components. As well as recommend conducting similar studies on other mathematics courses such as calculus, differential equations, probability etc.*

*Keywords: Concept-Rich Instruction, mathematical achievement, trends in mathematics, linear algebra, university students*

## INTRODUCTION

Mathematics curricula are among the most prominent curricula that occupy a central place in the education system. Based on its role in developing students' cognitive, skill, and emotional abilities. As well as its role in developing students' abilities to justify, prove and solve problems. As well as preparing a conscious and creative generation qualified with knowledge and skills in various fields, teaching mathematics in the third millennium needs to provide a fertile environment with mathematical concepts that the student needs to deal with its successive variables and successive developments (Wardat et al., 2021).

Mathematics is a discipline knowledge that has an essential role in human life. Learning math contains essential elements that must be mastered, namely "mathematical concepts." Draft Mathematics is an abstract idea that can classify or classify a set of objects (Godino, 1996).

The conceptual environment based on the components of Concept-Rich Instruction is considered an enrichment of the processes of thinking, analysis, and linking between them. As mathematics teaching is based on conceptual and procedural techniques, good mathematics teaches conceptual processes, followed by procedural techniques that achieve concept acquisition (Hurrell, 2021).

Accordingly, teaching mathematics well requires teachers to enrich their teaching environment with concepts. As the student is in, He is accustomed to the question formula, as he can achieve the highest marks if he learns the procedures only without an accurate understanding of the concept. However, sometimes understanding does not help him when the structure of the question changes (Clements & Sarama, 2016).

The teaching environment rich in mathematical concepts and terminology enriches mathematics and understanding concepts. So improving the student's achievement and changing students’ attitudes towards mathematics will contribute to achieving continuous education that enables them to face future challenges and deal with the changes of the current era (Tomson, 2021).

Mathematical concepts are necessary for students to build mathematical knowledge well. So practice, employ, and modify the learners' ideas, perceptions, and explanations for misunderstanding mathematical concepts. Thus understanding the concept makes mathematical topics more comprehensive and meaningful (Aloufi et al., 2021).

Ben-hur (M., 2006) believes that Concept-Rich Instruction stimulates active constructive learning to acquire mathematical knowledge. The mind is an active member responsible for providing experiences for students to learn building concepts that constitute continuous learning in mathematics. Whereas (Kusmayanti, I, Sumantri, S. & Noornia, A., 2018) see concept-rich instruction as active processes by which students organize, construct and recreate concepts presented to them in learning experiences time (Stoica & Wardat, 2021).

Teaching through a teaching strategy based on the components of Concept-Rich Instruction is based on directing students to the experiences and applied situations of the concept. The Concept-Rich Instruction takes place through five stages as Ben-hur (M., 2006):

- Practice (application): It means that learning concepts require adequate and appropriate practice by enriching the mathematics teaching process with as many examples, exercises, and new activities rich in concepts, sufficient repetition, reflective thinking, and concept visualization (Abdallah & Wardat, 2021).
- Context: by discussing the students' ideas, taking into account their variation while solving the exercises and their diversity, and analyzing their common mistakes, the students must try a rich variety of applications to acquire the concept (Alarabi & Wardat, 2021).
- Meaning of concept: it means verbal expression, translation, and interpretation of the concept with words and symbols, so the role of the teacher here is as a mediator. The process of giving meaning to the concept within words or symbols is done by developing students' understanding of concepts through verbal thinking and expression, and the correctness of giving it the correct meaning expresses the student's understanding of it (Alotaibi et al., 2021).
- Re-contextualization (reframing the concept): i.e., linking new experiences with previous experiences and experiences and focusing on new applications of the concept where the concept is used to connect new experiences to prior backgrounds and experiences, and here the learner must be trained in that, and when re-contextualizing the mind must abandon about old experiences that are based on misconceptions (Jarrah et al., 2022).

- Verification (the understanding of the concept is achieved): Teachers must encourage students to move to new experiences through the curriculum and fundamental problems; that is, students must transfer what they have learned and understand from concepts and apply them in the natural environment.

There are some factors affecting student's achievement related to the teachers and instruction; The teacher has an essential role in the students' achievement through their characteristics and his ability to diversify with modern teaching strategies. He deals with students, taking into account individual differences and avoiding prejudice (Akhmedov, 2021)

It is necessary to look for the best teaching strategies, methods, and approaches that improve students' achievement at various academic levels to grow in love with mathematics and achieve the highest cognitive and skill achievement performance (Tashtoush, M., Shunaq, M. & Barakat A., 2020 ).

Attitudes are among the psychological variables that play an essential role in achieving the highest levels of achievement among students and affect learning gains and outcomes. They are an indicator of the individual's psychological and cognitive readiness to understand, employ and deal with the learning content available to him. Psychological and mental stimuli make the student accept the educational material (Pandita, 2021).

Attitudes are one of the subjective components that can be learned and acquired through the experiences that the student is exposed to in different contexts. They are one of the most important emotional aspects that the curricula seek to develop and develop among students. It affects their learning motivation and stimulates their desire to master the learning content (Puspitarini & Hanif, 2019). The importance of measuring attitudes towards mathematics lies in identifying students' attitudes and trying to modify, develop, improve and enhance negative ones, as forming positive attitudes towards.

Learning mathematics is one of the important goals to determine students' desires. They wish to study in the light of their attitudes towards mathematics, as they try to avoid studying mathematics as much as possible when their attitudes are negative towards it or vice versa. In addition to anticipating students' will achieve good in mathematics - in light of their attitudes towards it. Sometimes the achievement is linked to trends within certain limits (Siagan et al., 2019).

The trends towards mathematics differ in the degree of their strength and weakness. They can be represented by the natural number line, where the positive direction represents acceptance, the negative direction represents rejection, and the number zero represents the neutral direction. And negative trends represented in the individual's rejection of a position or something, and neutral trends represented in the individual's behavior and freedom to accept or reject a position or something.

The mathematics instruction closely relates to the students' attitudes towards mathematics. The teachers determine the students' demands. The attitude towards mathematics includes the students' orientation towards the teacher's instruction. The teacher's most crucial objective of mathematics teaching is to direct and activate the student's behavior in situations that require him to respond with acceptance or rejection. (Wittmann, 2021).

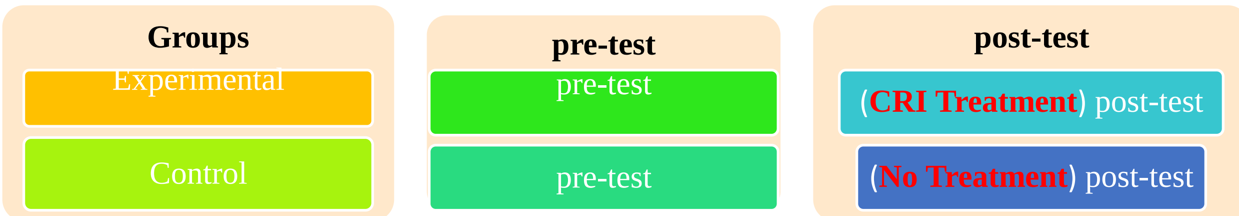
Educators believe that positive trends toward mathematics in the early age stages are critical in the teaching process because it determines the student's behavior and often predicts student success. Childhood is the stage of establishing, forming, and forming identity. The student's cognitive structure occupies a central place in his actions and helps him determine his inclinations and interest (Kalogiannakis & Papadakis, 2019).

The importance of searching for the best strategies, methods, and educational entrances comes from the importance of mathematics and its role in the progress of societies. It is an important topic that occupies an essential space in imparting mathematical skills that enable individuals to make decisions quickly and easily and works to solve many problems that confront society so that society becomes The human being is a scientific and technical society. (Tashtoush, M., Alshunaq, M., & Albarakat, A., 2020 b).

(Linn, M., Kessel, C. & Slotta, J. Linn, M., Kessel, C. & Slotta, J., 2000) Believes that using the appropriate strategy has an important impact on learning mathematics. Students can learn mathematics more deeply if they use the right strategy. Mathematics teaching strategies have received unparalleled attention, especially those focusing on conceptual knowledge at the beginning of the teaching process. As a result, the study sought to provide answers to the following questions:

1. Is there a significant difference in the mean scores of the experimental and control groups on a mathematical achievement test due to the teaching method (the components of Concept-Rich Instruction versus the traditional way)?
2. Is there a significant difference in the mean scores of the experimental and control groups on the students' attitude scale due to the teaching method (the components of Concept-Rich Instruction versus the traditional way)?

**FIGURE 1**
**DESIGN OF THE STUDY**




*Study terms*: The study includes the following procedural definitions:

*Concept-Rich Instruction*: a set of teaching procedures based on a set of activities based on conceptual and procedural knowledge, and it consists of five components: (practice, diversity of contexts, re-context, giving meaning to the concept, verification).

*Achievement*: The student's grade when responding to the mathematical test prepared by the researcher in this study.

*Attitudes*: the total score obtained by the students on the scale of attitudes towards mathematics prepared by the researcher in this study.

## LITERATURE REVIEW

### Concept-Rich Instruction Previous Studies

Kelly & Licona (2018) conducted a study to reveal the level of conceptual understanding of the derivative among students of three universities in Jordan and their difficulties while solving mathematical problems. The study sample consisted of (170) students from the faculties of science and engineering, a test of conceptual understanding of the derivative was applied. The results showed a significant decrease in conceptual knowledge of the derivative, the understanding of the derivative in the context of symbolic, numerical representations, the awareness of the relationships between the derivative, the rate of change, and the termination of the students. In contrast, the students' level came to a mean in the conceptual understanding of the derivative in the context of physical and structural representations, and their awareness of what relationships between the derivative and the secant and the tangent, the results also showed many difficulties that students face while solving practical problems in life contexts on the derivative (Kelly & Licona, 2018).

Kusmayanti and others (Kusmayanti et al., 2018) also conducted a study to identify the effect of concept-rich teaching on the ability to study mathematics among primary school students who suffer from mathematical anxiety. The study sample consisted of (90) students in a Jakarta school. They were divided into two equal groups. An experimental group was taught using the teaching method rich in mathematical concepts, and a control group was taught using the traditional way. A measure of mathematical anxiety and a test of mathematical ability was prepared. The results showed statistically significant differences in the students' mathematical skills due to the variable of the group and in favor of the experimental group that studied the teaching method rich in mathematical concepts (Hamad et al., 2022).

The results also showed an interaction between mathematics instruction and mathematical anxiety in learning mathematics and that students with high skills in learning mathematics and low mathematical anxiety were those who studied with concept-rich instruction. And that the levels of mathematical anxiety among students who studied with the concept-rich instruction were lower than the level of mathematical anxiety among students who studied with the traditional way.

Hidayat and Iksan (2015) conducted a study to identify the impact of mathematics education in realistic conceptual contexts on conceptual understanding and mathematics achievement in the subject of linear programming in Indonesia. The researchers used the quasi-experimental approach and applied a test in Conceptual comprehension and the other in mathematical achievement on the study sample that consisted of (65) male and female high school students. The results showed statistically significant differences in favor of the experimental group on the conceptual comprehension and mathematical achievement tests. The results also showed a statistically significant relationship between conceptual understanding and mathematical achievement in linear programming. In the experimental group, the misunderstanding of linear programming was less than the misunderstanding of the control group students. The implications of this study were practical for teachers to help their students with conceptual understanding, for mathematical concepts through open-ended questions (Hidayat, R., & Iksan, Z., 2015).

Yee and Bostic (Yee, S. & Bostic, J., 2014) conducted a study to reveal the impact of the re-contextualization skill in the content of problem-solving on its solution in terms of concepts, context, and practices among middle and high school students. The study sample consisted of (6) students from the two stages in each stage (3) students, and the researchers conducted interviews with the students and implemented a test to solve the problem. The researcher analyzed the problem-solving in terms of re-contextualizing, mathematical problems, conceptual content, re-contextualization through symbols and conceptual metaphors. The results showed that the students could return the problem's context from a conceptual context to a more symbolic context than a non-symbolic representation. The results also showed that multiple contexts contribute to conceptual understanding and representation while solving the mathematical problem.

Petrou & Goulding (2011). also conducted a study that aimed to identify the importance and use of mathematics teachers in the intermediate stage of some teaching models in teaching mathematical concepts and the obstacles to their use. Medium degree, and that the degree of importance of these teaching models from the teachers' point of view came to a medium degree. The obstacles to using some of these teaching models came to a medium degree from their point of view (Petrou & Goulding, 2011).

In the same context, Popoola & Oyinloye (2013) conducted a study to identify the impact of prior knowledge on developing vocabulary and understanding mathematical concepts in schools in western Nigeria. The researchers used the quasi-experimental approach; the sample consisted of (260) students divided into two equal groups: an experimental group subjected to a teaching strategy based on retrieving prior mathematical knowledge and a control group that studied traditionally. A mathematics test was conducted for both groups. The study results showed that the experimental group's performance was better than the control group's performance on the test. Also, prior knowledge and a good prior understanding of mathematical concepts help develop students' knowledge of new mathematical concepts (Popoola & Oyinloye, 2013).

The study of Khashan (2013) aimed to identify the effect of using conceptual learning on the achievement of ninth-grade students in mathematics in Jordan. The study sample consisted of (141) male and female students, distributed into two experimental groups of (72) students. A female student was taught using the conceptual learning strategy, and a control group of (69) male and female students were taught using the traditional method. The study results showed statistically significant differences due to the application of the conceptual learning strategy in favor of the students of the experimental group. At the same time, there were no statistically significant differences due to gender or the interaction between method and gender. The results also showed that students at each of the three levels of achievement (high, medium, And low) in the experimental group are better than their control group counterparts. At the same time, there were no statistically significant differences between the students of the two groups due to gender or the interaction between method and gender at each of the three levels of achievement.

Bottge and his colleagues conducted a study aimed to identify the impact of an environment rich in mathematical problems; the study sample consisted of students In the middle school in Taiwan, (14) students enrolled in a remedial course in mathematics who diagnosed these students as having learning difficulties in mathematics. The results showed that an environment rich in problems and practice improves mathematical concepts (Bottgeet al., 2011).

Simorangkir (2021) conducted study aimed to verify: (the level of conceptual and procedural understanding in algebra among secondary school students in Malaysia, the relationship between conceptual and procedural knowledge in understanding algebra, and the relationship between Conceptual and procedural knowledge within mathematics teaching instructions. The study sample consisted of (132) male and female students, and an algebra test consisting of (14) items was used that measures procedural and conceptual knowledge. Procedural and the results of the study showed that the students' level of conceptual comprehension was low; on the other hand, there was a rise in students' procedural awareness, and the results showed that there is a strong positive relationship between theoretical understanding and procedural understanding in solving algebra problems (Simorangkir et al ., 2021).

Concerning the studies conducted on undergraduate students, specifically in the subject of calculus, both Scheja and Patterson (2010)conducted a study aimed at identifying the impact of context on the transformation of conceptual understanding from theoretical to applied in the subject Calculus; the study sample consisted of (20) students of the calculus course at Stockholm University in Sweden. Interviews were conducted with the students to clarify how their concepts developed. It works on forming the basic building block in understanding the concept. The broadening of the theoretical frameworks of the students was better in linking theoretical information to understanding the concepts related to the subject of calculus. By reviewing the previous studies related to the topic of the current study, most of the studies dealt with the conceptual approach and understanding the mathematical concepts (Wardat et al., 2022). Concept-rich teaching on studying mathematics among middle school students who suffer from mathematical anxiety. Some studies touched on the components of Concept-Rich Instruction- instruction in mathematical concepts such as application, practice, and re-context (Scheja & Pettersson, 2010).

## METHODOLOGY

The current study adopted the quasi-experimental approach with two groups; an experimental group that was taught using the components of Concept-Rich Instruction and a control group that studied according to the traditional way. And the implementation of math test and attitude questionnaire.

### Participants

It was among the students registered for the Linear Algebra course for the first semester 2021/2022 at Al-Hosn University College, where two divisions were chosen by the intentional method; The first represents an experimental group that is taught according to the components of Concept-Rich Instruction numbering (55) male and female students, and the control group that is taught according to the traditional method, and their number is (57) male and female students.

**TABLE 1**
**PARTICIPANTS OF THE STUDY**

| Groups | Male | Female | Subtotal | Overall total |
|---|---|---|---|---|
| Experimental | 25 | 30 | 55 | 112 |
| Control | 29 | 28 | 57 | |

## Instrument

*First: The Mathematics Test*

The test items were prepared from a literature review (Anton, H., 2000; Kolman, B., 2000), consisting of (25) multiple-choice items according to Bloom's taxonomy. The first four cognitive: (Remember, Understand, Apply, Analyze), the test contain mathematical tasks. A specification table was prepared for the test. One mark was given for each correct answer of the test items. Zero for the wrong answer, and thus the value of the scores on the test ranged from (0) as a minimum and (25) as a maximum (Jarrah et al., 2020).

To verify the validity of the tool, it was presented to a group of arbitrators from Jordanian university professors specializing in mathematics, mathematics education, measurement, and evaluation, and asked them to express their opinions and observations about its suitability for the objectives for which it was set, and the suitability of tasks to the areas they measure, as well as their scientific accuracy. And based on the opinions of the arbitrators and in the light of their observations, some test Items were modified to suit the achievement test until the test became its final form. The difficulty and discrimination coefficients of the test were also investigated by applying it to an exploratory sample and calculating the difficulty coefficients and discrimination coefficients for the Items to analyze the students' answers to the test. The difficulty coefficients ranged between (0.50-0.77), while the discrimination coefficients ranged between (0.35-0.72). These values are appropriate (Quaigrain & Arhin, 2017).

To verify the Reliability of the test, it was applied to an exploratory sample. The reliability coefficient was calculated by the test-retest method. It was used twice with a time difference of two weeks between the two applications. The Pearson's correlation coefficient values were calculated between the students' total scores in both times of the application. It was found that the correlation coefficient is equal to (0.92). This value confirms that the cognitive achievement test has reliability indications that allow it to be used for this study (Quaigrain & Arhin, 2017). The required time was also calculated by applying it to the exploratory sample by finding the mean of the time needed by all students. The time required to use the Mathematical Achievement Test was (60) minutes.

*Second: Mathematics Attitudes Scale*

The Attitudes towards Mathematics Scale was developed by referring to previous studies (Al-Hwaiti, 2011, Shtayat, 2017), where the scale in its final form consisted of (20) items on the triple-graded Likert scale: (Agree, Neutral, Disagree) For these options, scores (3, 2, 1) are assigned in order. The scale also included five Dimensions representing the components of Concept-Rich Instruction (practice, context diversity, re-context, giving meaning to the concept, verification), and four Items were allocated to each Dimension with a sub-maximum degree for each Dimension (12). The maximum score for the scale as a whole was (60).

The scale's validity was verified by presenting it to a group of arbitrators to take their observations. The observations submitted by the specialists were taken in terms of the extent to which the Items of the scale were achieved study purposes, the integrity of the language, clarity, accuracy, and comprehensiveness.

The scale's reliability was also verified by finding the internal consistency reliability coefficient using Cronbach's alpha equation after applying the scale to the exploratory sample, where the internal consistency reliability coefficient for the overall scale was (0.77). These values are suitable for this study (Allam, 2016).

## Treatment and Procedures

To achieve the study's purpose's, its procedures were implemented according to the following steps:

- The theoretical and literature review related to this study was reviewed and used in preparing study tools and educational material.

The theoretical literature and previous studies related to this study in international journals, periodicals, and abstracts related to the problem of the study were also reviewed.

- The study population was determined by referring to the admission and registration unit records at Al-Hosn University College. The study sample was selected from the students enrolled in the linear algebra course in the first semester of 2021/2022 before implemented the two study tools.

- The study tools were prepared in their initial form, judged and verified for their validity and reliability, then reformulated and modified based on the arbitrators' committee's recommendations, proposals, and opinions. The educational material was chosen from the linear algebra course to implement the study through it. It was re-designed and developed according to the components of Concept-Rich Instruction to teach the students of the experimental group by the same researcher.
- The two study tools were implemented to the exploratory sample selected from the study community and from outside its sample before starting the implementation of the study. The validity and reliability coefficients, the coefficients of agreement, difficulty, and discrimination for the students' grades were calculated with a time difference of two weeks between the two implementation on the exploratory sample.
- The researcher made a pre-test for study groups (experimental and control) in the first week of the first semester of 2021/2022.
- The researcher himself taught the experimental group of the educational material according to the components of the Concept-Rich Instruction at the beginning of the first semester of 2021/2022 and throughout (16) consecutive weeks, with (48) lectures of (50) minutes each. The researcher also traditionally taught the control group during the same period.
- The post-test of the two study tools was carried out at the end of the sixteenth week of the first semester of 2021/2022 by the researcher on the two study groups after teaching the educational material.
- The math test and Attitudes Scale were corrected, and the final grade was monitored for each student. And analyze the results using the Statistical Package for Social Sciences (SPSS) program to answer the two questions of the study, compare them with the results of previous studies, and provide results and recommendations.

**Data Analysis**

The analysis of data was carried out using parametric statistical tests; Descriptive Statistics of the variables treated in the Study, t-test. The post-test score for linear algebra skill was subjected to Analysis of Covariance (ANCOVA) using pre-test scores as covariates. The benefit of ANCOVA is to "statistically control" for a third variable known as a confounding variable. A p-value of less than 0.05 was considered to be statistically significant.

## FINDINGS/ RESULTS

The means and standard deviations were calculated for the two groups, the pre, and post, for the results of the Mathematical Test, according to the teaching method variable. Table (1) illustrates this.

**TABLE 2**
**DESCRIPTIVE STATISTICS FOR THE MATHEMATICS INVENTORY TEST**

| Variable | Groups | N | Mean | SD |
|---|---|---|---|---|
| Mathematics inventory test | Control pre-test | 57 | 4.52 | 2.306 |
| | Control post-test | 57 | 9.19 | 1.955 |
| | Experimental pre-test | 55 | 4.48 | 2.163 |
| | Experimental post-test | 55 | 15.55 | 1.525 |

The highest mark of the mathematic Test (25)

**FIGURE 2**
**STUDENT'S ACHIEVEMENT IN THE POST-TEST FOR BOTH STUDY GROUPS**

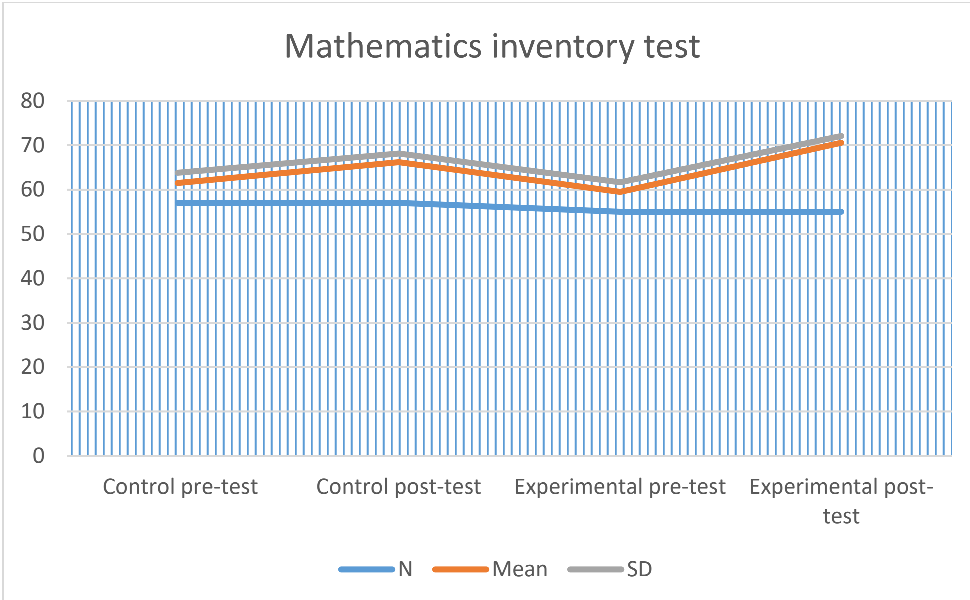



Table (2) and figure (2) shows an improvement in the student's achievement in the post-test for both study groups. There are differences in the means on students' performance in the post-test.

The post-experimental group was (15.55), while the mean of the control group was (9.19), as well as the standard deviation of the mathematics test for the experimental group was (1.525) and the control group was (1.955).

The one-way (ANCOVA) was used. The effect size was computed in the post-test for both groups (experimental and control).

After neutralizing the effect of their pre-measurement (accompanying variable), and Table (2) explains it.

**TABLE 3**
**ONE-WAY ANALYSIS OF VARIANCE (ANCOVA) AND THE EFFECT SIZE OF THE MATHEMATICS TEST BETWEEN THE TWO GROUPS**

| Source | Type sum of squares | df | Mean Square | F | Sig | Partial Eta Squared | Size effect |
|---|---|---|---|---|---|---|---|
| Group | 521.26 | 1 | 521.26 | 54.58 | 0.017* | 0.478 | Medium |
| Error | 951.57 | 110 | 9.55 | | | | |
| Total | 1472.83 | 111 | | | | | |

* Significance at $\alpha = 0.05$

Table (3) shows there are statistically significant differences at ($\alpha = 0.05$) between both groups in the test due to the effect of the teaching method (the components of Concept-Rich Instruction versus the traditional method).

All differences favored the experimental group that was taught using Teaching components rich in mathematical concepts. In order to reveal the effectiveness of self-organized learning in improving the achievement of the study sample members, the effect size was found using the Eta square ($\eta 2$), which was found to be equal to (0.478), and this indicates that the use of teaching components rich in mathematical concepts explains about (47.8%) of the variance in improvement. The achievement of the study sample members, while the rest of the variance (52.2%) is not explained and can be due to external influences or other factors.

***Second question:*** Is there a significant difference in the mean scores of the experimental and control groups on the students' attitude scale due to the teaching method (the components of Concept-Rich Instruction versus the traditional way)?

To achieve this goal, the mean and standard deviations of the two implementation, the pre, and post, were calculated on the trends scale according to the teaching method, and Table (4) shows that. Table (4): Mean and standard deviations of the two implementation, before and after, on the trends scale as a whole and on each of its five dimension (practice, context diversity, re-context, giving meaning to the concept, verification).

**TABLE 4**
**DESCRIPTIVE STATISTICS FOR STUDENTS' ATTITUDE SCALE**

| Groups | | | Practice | context | Meaning of concept | Re-contextualization | Verification | Overall |
|---|---|---|---|---|---|---|---|---|
| Experimental | Pre test | Mean | 8.51 | 8.17 | 87.94 | 9.01 | 8.96 | 42.24 |
| | | SD | 2.62 | 2.34 | 2.95 | 2.45 | 2.23 | 5.41 |
| | Post test | Mean | 11.68 | 11.53 | 10.94 | 11.24 | 10.76 | 51.88 |
| | | SD | 1.92 | 2.01 | 2.02 | 1.99 | 1.86 | 2.83 |
| Control | Pre test | Mean | 8.80 | 8.58 | 7.29 | 9.23 | 8.92 | 41.51 |
| | | SD | 2.39 | 2.19 | 2.33 | 2.79 | 2.68 | 4.94 |
| | Post test | Mean | 8.92 | 8.61 | 7.22 | 9.31 | 8.89 | 41.32 |
| | | SD | 2.36 | 2.30 | 2.58 | 2.66 | 2.72 | 3.08 |

The highest mark of the direction scale (60) and for each dimension (12)

Table (4) shows that there are differences in students' performance in all dimensions (practice, context diversity, re-context, giving meaning to the concept, verification), as follow the mean of the experimental group was (51.88). The mean of the control group was (41.32), while the standard deviation of the experimental group in the post-test was (2.83) and for the control group was (3.08).

To demonstrate the statistical significance between all dimensions, the multiple variance analysis (MANCOVA) was used to measure the trends for five dimensions (practice, context diversity, re-context, meaning to the concept, verification) between the two study groups. The results were as in Table (5).

**TABLE 5**
**MULTIPLE VARIANCE ANALYSIS (MANCOVA) FOR THE STUDENTS' ATTITUDE SCALE**

| Source | Components of Concept-Rich Instruction approach | sum of squares | df | Average | F | Sig | $\eta^2$ | Size effect |
|---|---|---|---|---|---|---|---|---|
| accompanying | Practice | 68.42 | 1 | 68.42 | 12.64 | 0.00 | 0.10 | Small |
| | context | 74.19 | 1 | 74.19 | 22.41 | 0.00 | 0.17 | Small |
| | Meaning of concept | 75.37 | 1 | 75.37 | 18.38 | 0.00 | 0.14 | Small |
| | Re-contextualization | 66.17 | 1 | 66.17 | 15.24 | 0.00 | 0.12 | Small |
| | Verification | 69.65 | 1 | 69.65 | 14.39 | 0.00 | 0.12 | Small |
| | overall | 1054.32 | 1 | 1054.32 | 32.40 | 0.00 | 0.23 | Small |
| Post test | Practice | 60.61 | 1 | 60.61 | 11.20 | 0.000* | 0.25 | Medium |
| | context | 21.99 | 1 | 21.99 | 6.64 | 0.032* | 0.17 | Medium |
| | Meaning of concept | 29.20 | 1 | 29.20 | 7.12 | 0.020* | 0.18 | Medium |
| | Re-contextualization | 18.81 | 1 | 18.81 | 4.33 | 0.016* | 0.15 | Medium |
| | Verification | 22.65 | 1 | 22.65 | 4.67 | 0.012* | 0.16 | Medium |
| | overall | 340.44 | 1 | 340.44 | 10.46 | 0.000* | 0.46 | Medium |
| Error | Practice | 590.40 | 109 | 5.41 | | | | |
| | context | 361.61 | 109 | 3.31 | | | | |
| | Meaning of concept | 447.66 | 109 | 4.10 | | | | |
| | Re-contextualization | 474.12 | 109 | 4.34 | | | | |
| | Verification | 528.35 | 109 | 4.84 | | | | |
| | overall | 3547.33 | 109 | 32.54 | | | | |

| | | | | |
|---|---|---|---|---|
| Corrected total | Practice | 52257 | 111 | 470.78 |
| | context | 30548 | 111 | 275.20 |
| | Meaning of concept | 44711 | 111 | 402.80 |
| | Re-contextualization | 45651 | 111 | 411.27 |
| | Verification | 38659 | 111 | 348.27 |
| | overall | 684247 | 111 | 6164.38 |

Table (5) shows a difference in the experimental group taught using the components of Concept-Rich Instruction compared to their peers in the control group who were taught traditionally.

The five dimensions (practice, context diversity, re-context, giving meaning to the concept, verification) indicate statistically significant differences between the two study groups in the dimension of attitude scale and its five dimensions mentioned.

## DISCUSSION

The finding regarding question 1 shows there are statistically significant differences at ($\alpha$ = 0.05) between both groups in the test due to the effect of the teaching method (the components of Concept-Rich Instruction versus the traditional method). This result may be attributed to the fact that teaching the topics of the Linear Algebra course needs to present many examples, activities, and diversification in the amount of practice and application, which helped students' progress in academic achievement.

The environment rich in mathematical concepts contributes effectively to students' learning. It allows them to give a good meaning to the mathematical concept through thinking and verbal expression to develop their understanding of concepts through what the components of Concept-Rich Instruction offer them in terms of defining the concept and then practicing it in various practical contexts and giving new meanings to it.

Also, their acquisition of the ability to reformulate the mathematical concept and link it to concepts, experiences, and previous experiences, focusing on practicing new concepts and connecting them to the natural environment. Yee & Bostic, 2014; Khashan and Khashan, 2013; Rabie et al., 2020).

It is also clear from the study results that most members of the experimental group have obtained high marks on the mathematical achievement test.

The exposure of the study sample to the skills of context diversity and re-contextuality has contributed significantly to the development of conceptual and procedural problem solving and the representation of the concept in various contexts while solving the mathematical problem, and this is consistent with the study of (Hidayat & Iksan, 2015; Popoola & Oyinloye, 2013; Scheja & Pettersson, 2010), which demonstrated that diverse contexts and their re-representation in similar contexts contribute to a good conceptual understanding and re-representation of the concept in realistic contexts in raising the level of mathematical achievement.

In light of the foregoing, and based on the results of several previous studies (Bottge, et al, 2011; Hidayat & Iksan, 2015; Ghazali & Zakaria, 2011; Scheja & Pettersson, 2010; Tashtoush, M., Shannaq, M. & Barakat, A., 2020 a; Rasheed, N. & Tashtoush, M., 2021) from the presence of an improvement in achievement, the researcher believes that this result can be due to the nature of the educational activities and exercises that were provided to the study sample members, which worked to arouse desire And enriching the environment of mathematical concepts to increase the amount of practice and application in similar contexts by encouraging them to move to new experiences and knowledge and transfer what they learned and understood from concepts and employ them in the natural environment, and this in turn contributed to raising the level of achievement and possessing sufficient experiences and knowledge that helped the study sample members to apply them in situations Similar, and this reinforced the positive effect of using the components of teaching that are rich in concepts, which made the study sample members feel comfortable when they were exposed to the various mathematical tasks in their contexts and ideas. In reviewing the study results, the main conclusion was reached that employing the components of Concept-Rich Instruction is one of the successful teaching approaches in raising the level of mathematical achievement among university students. That reliance on usual teaching methods and strategies depends on indoctrination, direct teaching, and memorization. It lacks a diverse strategy, which cannot contribute to a significant positive impact on the achievement of mathematics learning outcomes.

In light of this conclusion, it is necessary to note to the planners of the various mathematics courses in Jordanian universities the importance of subjecting mathematics teachers in universities to training courses and workshops to train them on how to use appropriate teaching strategies and programs, especially those that build on the components of teaching rich – instruction. The study also concludes that the use of teaching components rich in mathematical concepts in teaching is one of the appropriate strategies in improving the level of mathematical achievement in general and specifically in the field of linear algebra in particular, as it was found that there is clear and tangible progress in the level of students' achievement on the mathematical achievement test. The teaching components rich in mathematical concepts provided the study members with learning experiences that are difficult to provide in the traditional teaching method.

The results regarding question two shows a difference in the experimental group taught using the components of Concept-Rich Instruction compared to their peers in the control group who were taught traditionally.

The five dimensions (practice, context diversity, re-context, giving meaning to the concept, verification) indicate statistically significant differences between the two study groups in the dimension of attitude scale and its five dimensions mentioned.

This result can be attributed to the fact that the use of the components of Concept-Rich Instruction through the teacher enriching the educational environment with relevant concepts and the diversity of contexts with a massive amount of mathematical concepts related to the topics of the linear algebra course, the latest ability to form a large amount of mathematical concepts in the knowledge stock of the students and that the study sample members were exposed to the components of rich teaching such as giving meaning to the concept and re-contextualization, have contributed to the development of understanding and solving algebraic problems conceptually and procedurally, and the representation of the algebraic concept in various contexts in similar mathematical situations, all of which may have refined the cognitive outcome of the study members with a massive amount of The various mathematical concepts, linking them and transferring them to new experiences and real problems that required the students to employ them in similar environments, and this in turn achieved the skill of verification for them, which led to changing the negative view and strengthening the attitudes towards mathematics in general, and the subjects of the linear algebra course in particular. The improvement of attitudes among the students of the experimental group compared to their peers in the control group can be attributed to the use of development strategies to enrich the conceptual environment with mathematical concepts; Such as questions with a high level of mental abilities, analysis of mistakes committed by students, repetition of practice and application of the concept, giving students enough opportunity to answer and encouraging them to do so.

Concept-Rich Instruction, the more teacher enriches the conceptual environment, the greater the link between new and previous experiences to reach new applications of the concept and its ideas. In addition, the components of Concept-Rich Instruction were not limited to teaching students only concepts. Still, it led them to enrich their educational environments with conceptual applications so that the student can know the degree of his understanding of the concepts they work with.

Reconnecting math concepts with other dimensions reinforced the students' to understand them according to a specific mathematical context, developing an understanding of the concepts in a way that suits the educational situation to which the student is exposed and expanding his awareness by verifying the concepts that have been built in different contexts.

In view of the excellent level shown by this study, the researcher recommends directing faculty members in Jordanian universities to enrich the educational environment with mathematical concepts during the teaching process, improving academic courses with the necessary conceptual knowledge and procedural knowledge, and using faculty members for various teaching strategies, such as the teaching strategy rich in mathematical concepts in teaching their students.

The researcher also recommends conducting more similar studies on other mathematics courses such as calculus, equations, probability, and statistics for different stages and preparing training programs and workshops for mathematics teachers in universities and their students to improve their mathematical achievement and enhance their attitudes towards mathematics.

## CONCLUSIONS

The study aimed to investigate the effectiveness of a teaching strategy based on a Concept-Rich Instruction approach in the student's achievement in a linear algebra course and their attitudes towards mathematics. The study sample consisted of (112) male and female students divided into two groups. An experimental group of (55) male and female students taught using a teaching strategy based on Concept-Rich Instruction. A control group of (57) male and female students were taught traditionally. The study data were collected using a mathematical test and a questionnaire that measures students' attitudes towards mathematics. Appropriate methods confirmed the validity and reliability of the study tools. The study results showed statistically significant differences between the two study groups and in favor of the experimental group in the achievement test and the measure of attitudes towards mathematics. The study recommended using the Concept-Rich Instruction approach in teaching the linear algebra course to improve achievement, enhance students' attitudes towards mathematics, and invite students to use these components. As well as recommend conducting similar studies on other mathematics courses such as calculus, differential equations, probability, and statistics for different stages to verify the effectiveness of the teaching components rich in mathematical concepts.

## RECOMMENDATIONS

- Educators and instructors need to learn about CRI and to then, design and implement CRI for mathematics PSTs
- This research recommends further studies on CRI with various concepts at other levels of education, such as primary and secondary schools, and teacher colleges.
- This study addresses such challenges and suggests what can be done to improve learning achievements in mathematics. The same approach can be applied in other subjects such as chemistry and physics, which involve mathematical concepts.
- Designing and implementing classroom activities based on the five components of CRI. This will help to improve learners' development of their understanding of the mathematical concepts and achieve desirable learning outcomes.

## LIMITATIONS

The limitations of this study were as follows:

- This study was carried out in the first semester of 2021/2022.
- The study members represented students from engineering disciplines (mechanical engineering, chemical industries engineering, water, and environmental engineering, electrical engineering), who are at the first-year level of Al-Hosn University College students distributed

among two divisions of students registered for the linear algebra course, one of them is an experimental group. The other is a female group officer.

- This study dealt with a teaching strategy based on the components of Concept-Rich Instruction-mathematical concepts (practice, diversity of contexts, re-contextualization, giving meaning to the concept, verification). Its results use data collection tools and procedures, the nature of the community, and the sample.
- The study is determined by its tools and its psychometric properties of validity and reliability that are acceptable for scientific research purposes, which were prepared to achieve the study's objectives.

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