

The Effect of Using Divergent Thinking Strategies in teaching Complex analysis in Developing Self-Regulation Skills. (A Psychological Study on for Fourth-Grade Students in the Mathematics Department)

Ikhlas Elias Abdulaziz, Prof. Dr. Inas Younis Mustafa Al-Azzo, Prof. Taghreed Hamdoun Shukr

ekhlas.21esp43@student.uomosul.edu.iq

dr.enasalazwo@uomosul.edu.iq

Mosul University/College of Education for Pure Sciences

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Abstract:

The research aimed to identify the impact of teaching complex analysis with strategies of divergent thinking in the development of self-regulation skills for fourth-grade students, Department of Mathematics, Faculty of Education for Pure Sciences. Two zero hypotheses were formulated to verify this goal. The research was applied in the academic year 2022-2023 to a sample of fourth grade students in the Department of Mathematics/Faculty of Education for Pure Sciences. The sample amounted to (131) male and female students, (67) male and female students for the experimental group that studied the strategy based on divergent thinking and (64) male and female students for the control group that studied in the usual way. The researchers prepared a tool for measuring self-regulation skills consisting of 40 items distributed by (9) items for the skill of planning and setting goals, (14) items for the skill of self-monitoring, (4) an item for the skill of self-assessment, (7) an item for the skill of self-enhancement, and (6) an item for the skill of controlling external stimuli. Its Face validity was verified by presenting it to a group of arbitrators in the specialization of measurement and evaluation, teaching methods and educational psychology, and its reliability coefficient reached 0.88. The Pearson correlation coefficient and the test were adopted for two independent samples as statistical means in analyzing data. The research also made proposals for several studies to complement the results of this research, including: The use of complex thinking strategies in teaching Complex analysis has a high impact on the development of self-regulation skills of fourth-grade students in the Department of Mathematics. In light of this result, the researcher came to a number of recommendations, including training teachers of Complex analysis on teaching methods and emphasizing interest in educational methods, and activities. The research also made proposals for several studies to complement the results of this research, including: Effectiveness of hard thinking strategies in teaching Complex analysis in the Department of mathematics students.

Keywords : teaching Complex analysis , divergent thinking strategies, self-regulation skills

The problem of research: The presence of female researchers in the university field and their dealings with students and found that there is a complaint by students of some subjects in the Department of Mathematics and a survey of a group of students of the end stage for the year 2021-2022 who diagnosed difficulty in understanding some subjects, including complex analysis, for the overlap of their topics and concepts, and thus this was reflected in the results of their academic achievement in this subject. This is what was observed from the four success rates of the previous years, as it does not rise to the required level and students' search for sufficiency with the degrees of success in it. Al-Ba Hatat finds that this may be due to the traditional methods followed by the teachers of this subject, as it usually focuses on giving the largest role to the teacher to provide the lesson according to what is stated in the curriculum and avoids giving the largest role to the student according to.

On the other hand, they found that the term self-regulation skills is one of the educational concepts that have been recently circulated in the global and Arab educational research, but they are little traded in the specialization of teaching methods, especially in teaching mathematics, and this variable has not been disclosed to university students. Although self-regulation skills play a role in achievement and achievement of learning objectives and in learning complex scientific topics and concepts and can be used to raise the efficiency of learning and achieve integration between various teaching methods, the current reality indicates that there is a deficiency in some self-regulation skills, which was diagnosed by the results of previous local studies such as the study of Obaidi (2021) and Bayati (2022)

One of the recommendations that these conferences also emphasized is the development of university teaching methods towards giving the student the largest role and stimulating his thinking during lessons. Researchers find

that recent trends in teaching focus on linking academic content with thinking skills such as linking content with critical and systemic thinking skills, including linking with divergent thinking skills.

Thus, it was found that it is appropriate to adopt the skills of divergent thinking and put them within a teaching strategy to teach the subject of Complex analysis by distributing the roles between the teacher and the student and the diversity of the questions asked during the lesson to allow the student to be active and a good thinker, and this will probably be reflected in improving their performance in that subject and raising their academic achievement in it, as well as researching the possibility of influencing this method to develop their self-regulation skills.

The researcher covered the problem of the research with the following question:

What is the effect of teaching complex analysis with strategies of divergent thinking in developing self-regulation skills for students of the Department of Mathematics?

➤ **Research Significance.**

Day by day, the interest of the contemporary world in education, as one of the most important tools of civilizational construction and economic, social and political changes required, as it is an important means of preparing the human element that forms the basis for the process of economic and social development, and its task has become very large because of the continuous change and development in a world where ideas are growing and knowledge is expanding at a staggering speed.

(Al-Khazandar, 2016: 2)

Therefore, those working in the field of teaching methods have spared no effort in searching for all the methods and methods that work to develop the teaching and learning processes, and sought to be the teacher who is looking for all the modern strategies and methods of teaching through which to move away from the old methods that make the learner a receiver and his role is limited and based on listening and receiving information only.

Abu Zeina and Ababneh (2010) pointed out that one of the main functions of education is to develop the ability to think among students at all school levels and in all subjects. Mathematics is a central position between subjects and in assuming responsibility. Training and teaching thinking and justification is one of the pillars of the basic processes on which mathematics education is based. The criterion of thinking is one of the main process standards in the document of principles and standards of the National Council (NCTM, 2000) (Abu Zeina and Ababneh, 2010: 271)

Complex analysis is a branch of mathematics that arose from the study of analytic functions with one or several variables. He began with Riemann's important discoveries in the mid-19th century, as a continuous and rapid shift began towards the study of the comprehensive properties of analytical functions based on topological methods and algebraic geometry, making this complex analysis one of the foundations of the contemporary development of mathematics, which is characterized by the integration and full and integrated synthesis of ideas. Quba, P.T. :143)

Learning to think is of great importance, it helps to raise the intellectual competence of the learner, and it can also improve the level of thinking among students, as it has become recognized that thinking is a skill that can be developed, in addition to its role in linking students to reality and developing their ability to use thinking skills in their daily lives, as well as students gaining a sense of conscious control over their thinking, and improving their self-confidence and their abilities to confront problem situations. Studies have shown that teaching thinking skills raises the degree of excitement and attraction towards science, learning and life in general. (Ovaries, 2011 :84)

Divergent thinking plays an important role in improving the issuance of divergent responses that help in the emergence of creativity, and on the other side of divergent thinking is limited convergent thinking, which is represented in remembering, understanding, application and analysis, which is an important thinking in the educational process taking into account not to stop, and to go beyond it to the development of divergent thinking, as convergent thinking is the basis for the practice of divergent thinking, which requires intellectual departure and openness to ideas and authorship between distractions (Shihata, 2012: 188-189)

Due to the importance of divergent thinking and its role in leading the mind to create new connections and convergences between nerve cells, forming pathways that allow many connections between the contents of the neurons that make up the structure of the mind, many concepts have changed about rich learning, which should be available within the framework of educational institutions, their programs, curricula and various courses. Thus, teaching and learning processes must not only ensure that learners absorb the content of the scheduled learning, but also open new pathways of thinking through neurons on the brain's neural network and ensure that this shift in educational thought occurs, through the performance of teachers and the emergence of clear evidence in the performance of learners. Therefore, the modernization of educational concepts in our

educational institutions requires the use of divergent thinking in the mechanisms of educational learning programs and the adoption of each of the following in order to liberate the potential of the human mind among learners .(Shehata ,2012: 188-189)

One of the teaching strategies that emphasize the implementation of thinking is the strategies of divergent thinking. Interest in divergent thinking strategies has increased as a natural result of the studies and research conducted on the human mind in recent years, as it revealed new horizons for teaching that liberate the mind of students while training them to speed up effective and appropriate responses to the nature of different situations. (Mohammed,2018: 126)

Gharawi (2010)pointed out that developing students' self-regulation skills helps them improve their performance. Learners who possess self-regulation skills are able to make the right decisions and integrate well with the group. They also have a responsibility towards their own work and they have a branch of thinking and self-reinforcement, so they are able to self-assess their performance, as well as they can integrate the various means of education and are classified as a metacognitive individual. (Mohammed ,2020 :164)

Based on the above, and in line with global trends in the integration of thinking skills and strategies in the academic content and teaching, and the importance of self-regulation skills in learning, it is hoped that this study will contribute to the search for some factors and strategies based on thinking, including divergent thinking in the development of self-regulation skills among students of the fourth stage in the Department of Mathematics.

➤ **Research Objective:** The research aims to identify:

The impact of teaching complex analysis with strategies of divergent thinking in the development of self-regulation skills for students of the fourth grade, Department of Mathematics, Faculty of Education for Pure Sciences.

➤ **The hypothesis of the research:** To verify the objective of the research, the following two null hypotheses were formulated:

1- There is no statistically significant difference at the level of ($\alpha \leq 0.05$) between the average degrees of development of self-regulation skills for the students of the experimental group that studied the strategies of divergent thinking and the students of the control group that studied in the usual way."

2- There is no statistically significant difference at the level of ($\alpha \leq 0.05$) between the means of self-regulation skills for the scores of the pre- and post-tests among the students of the experimental group that studied the strategies of divergent thinking.

Research Limitations: The current research is determined by:

- **Human Boundaries:** Fourth-grade students in the Department of Mathematics.
- **Spatial boundaries:** University of Mosul / Faculty of Education for Pure Sciences/ Department of Mathematics.
- **Time limits:** The first semester of the academic year 2022-2023.
- **The limits of mathematical knowledge:** Chapters I, II, III and IV in the book of Complex analysis . (Iron and Said,1982)

Substantive limits: consisting of:

- Divergent Thinking Strategies: (Virtual Thinking Strategy, Reverse Thinking Strategy, Applying Different Symbolic Systems Strategy, Symmetry Strategy, Perspective Analysis Strategy, Complementary Strategy, Network Analysis Strategy)
- Self-regulation skills: (planning, objective setting, self-monitoring, self-assessment, external stimulus control, and self-enhancement skills).

➤ **Terminology Definitions:**

1- The researchers define the teaching strategy according to the procedural thinking as: The group of regular moves carried out by the School of Complex analysis to generate many different ideas on the subject of the lesson among fourth grade students in the Department of Mathematics by receiving and organizing them with mathematical knowledge and integrating it into their cognitive structure and linking it with their previous experiences by integrating in answering the complex and varied questions in the lesson .

(self-regulatory skills)

The researcher defined the skills of self-regulation procedurally as: It is a systematic process carried out by the fourth grade student in the Department of Mathematics to control and control his behavior to perform a task required of him by directing his attention towards the task he performs through planning, setting objectives ,self-monitoring ,then checking the extent of his progress and diagnosing weaknesses and strengths to reach his objective while giving feedback on positive behavior in order to strengthen himself as well as his ability to adjust external stimuli and measured by the degree to which he gets his answer on the scale prepared for the purpose of measurement .

Previous studies: The following scheme include a presentation of a number of previous studies that the researchers reviewed for the research variable (strategies of divergent thinking) and (self-regulation skills). Thepresentation was made in a way that clarifies the title of the study, its purpose, sample, tools, and the most important results reached .

Scheme (1) Previous Studies of Divergent Thinking Strategies

El Sayed (2014 :245-255) conducted in Egypt	1- A program based on strategies of divergent thinking in teaching mathematics to develop the strength of mathematics and some habits of mind among middle school students		
The most important findings of the study are as follows:	research tool	The Study Sample	The purpose of the study
The results indicated that there are statistically significant differences between the mean scores of the students of the experimental study sample who studied the proposed program based on the strategies of divergent thinking in the pre and post applications to test the mathematical strength as a whole and in its sub-dimensions separately in favor of the post application	The study tool was the Mathematical Strength Test and the Test of Brain Habits	The study sample consisted of (41) pupils from the second preparatory grade at Nasiriyah Preparatory Joint School in Zagazig, which represents the experimental study sample that studies the proposed program based on crotch thinking strategies	This study was conducted to identify the effectiveness of a proposed program in mathematics based on strategies of divergent thinking on the development of mathematical power and some habits of mind among students of the second grade middle school.

Scheme (2) Previous Studies of Self-Regulation Skills

(Hassan, 2020 : 821-896) Conducted in Egypt	2-Effectiveness of a proposed strategy based on micro-content learning via mobile to treat common mistakes in writing,and improve self-regulation skills among first grade preparatory students		
The most important findings of the study are as follows:	research tool	The Study Sample	The purpose of the study
After analysis and interpretation,	As well as the study tools before and after the two study groups: the test of writing skills to treat common mistakes in the first grade preparatory	The researcher used the experimental approach, and adopted the semi-experimental design with	This study aimed to measure the effectiveness of a proposed strategy

the results showed the effectiveness of the proposed strategy in developing the two variables of the study.	students, and the scale of self-regulation skills. The scale consists of (40) phrases distributed over five axes, which were distributed as follows: defining the objectives of tasks (5) phrases), planning the implementation of tasks (3) phrases and organizing the implementation of tasks.) 9Phrases), performance monitoring and control when executing tasks (11) Phrase, and performance evaluation (12) Phrase.	the two control groups, the experimental , the pre- and post-applications, so that the control group studies in the traditional method followed and the experimental group is studied according to the steps specified in the The proposed strategy and number of (21) schoolgirls.	based on micro-content learning via mobile in treating common mistakes in writing , and improving self-regulation skills among first graders.
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Search procedures

First: Experimental Design Selection:

The researchers have adopted an experimental design with two pre and post tests of the self-organization variable. This design is called the Equivalent Groups Design because it suits this research and achieves its objectives as shown in the chart (3) in the below:

Scheme (3) Experimental Design of Research

Group	Pre-test	The independent variable Teaching according to	Post-test	The dependent variable
Experimental group	Self Regulation Skills	Divergent thinking	Self-Regulatory Skills Scale	Developing self-regulation skills
Control group		Routine method		

Second: Sample Selection of the Research

Two divisions of the research community were selected in a simple random manner consisting of 131 male and female students, 67 male and female students from the CD Division, which was randomly selected to represent the experimental group and 64 male and female students in the AB Division as a control group.

Third: Equivalence of research groups

The researchers were keen on statistical equivalence in variables that are believed to affect the course of the experiment and its control, as the arithmetic mean and standard deviation of each variable were calculated and then the t-test was used and the results were included in the following table:

Table(1) Results of the T-test for valence variables

Variables	Group	No.	Arithmetic mean	Standard Deviation	Calculated T value	Sig
Age	Experimental group	67	23.5075	2.76544	-.563	574
	Control group	64	23.7344	1.69258		

Modified	Experimental group	67	71.2652	8.89413	939	349.
	Control group	64	69.6961	10.12711		
Skill	Experimental group	67	93.3134	11.07031	.811	419
	Control group	64	91.7969	10.28974		
IQ.	Experimental group	67	41.8650	3.76940	1.042	.121

It is clear that all the significant values ((Sig) are greater than the level of significance (0.05) ,this means that there is no statistically significant difference between the means of the research sample in these variables , and thus the two groups are equivalent.

Fourth: Research Requirements

For the purpose of achieving the objective of the research and its hypotheses required the creation of a number of requirements, namely the identification of the scientific material (content) and then the formulation of behavioral purposes amounting to (257) behavioral purpose of Bloom classification of the first three levels (remembering, understanding, application, analysis ,synthesis). Represents (17%, 17%,25%,41%) respectively. The scientific material was then analyzed for the purpose of determining the appropriate divergent thinking strategy. Then, a teaching plan was prepared for the experimental group according to the steps of the strategies of divergent thinking and their steps as follows:

1. Preparing students' minds for the new topic by asking a set of questions that provoke open discussions and dialogues and continuing ideas by linking previous ideas with new ideas.
2. Presenting the lesson by asking various questions and according to the scientific content successively, taking into account the diversity of the presentation and stimulating the student's thinking.
3. The teacher extracts the most important ideas related to the subject of the new lesson and records them on the board .
4. Introducing students to the strengths and weaknesses of their thinking and correcting their course .

The teaching plan prepared for the control group was organized according to the usual method, andthere were (12) plans for each group and it is ready for implementation.

Fifth: Research Tools: The scale of self-regulation skills was prepared through the following stages: defining the objective of the items and then determining the content of the items by exposing the researchers to the educational and psychological literature in relation to this variable, and the measures of previous studies as they identified five skills: The skill of planning and setting goals, self-monitoring, self-assessment, the skill of adjusting external stimuli, the skill of self-enhancement, and the Face validity of the scale was verified by presenting it to a group of arbitrators and specialists in the field of measurement and evaluation and methods of teaching and educational and psychological sciences, as all items obtained an agreement rate of 80% and more. The statistical analysis was also carried out on an exploratory sample from outside the research sample for the purpose of finding the relationship between the items in the total degree to ensure the validity of its construction using the Pearson correlation coefficient and all correlation coefficients were high .Then it was confirmed that the items were distinguished using the T-test of two independent samples to test the difference between the mean of the upper and lower groups and it was found that all of them are statistically significant and distinct .

The scale reliability was verified by calculating the Fakronbach coefficient (Alpha-Coefficient)) andreached 0.88 if it is sufficient and satisfactory, and the number of final items of the scale (40) distributed over the five skills.

Thus, the self-regulation scale is ready to be applied to the research sample. For the purpose of correcting the self-regulation scale, the researchers gave scores of 1,2,3 respectively against the alternatives of the answer

(large , medium , small). Thus, the degree of self-regulation scale ranged between 40-120degrees with an average hypothesis of 80degrees.

Sixth: Application of the experiment: The self-regulation scale was applied beforehand on (13/10/2022), then I started the actual teaching of the experiment on Sunday (16/10/2022), as one of the researchers studied the two research groups according to the teaching plans prepared for each group, and it lasted until (5/1/2023), then I applied the self-regulation scale (post) on (8/10/2022)

Seventh: Statistical means: The following means were used: T-test for two independent samples: equivalence of the two groups, discrimination of self-regulation and verification of the research hypothesis. And the Alpha-Cronbach equation .To find reliability as well as Pearson correlation coefficient to calculate the relationship of the vertebra to the total score of the self-regulation scale.

Presentation and discussion of the research results: To verify the first hypothesis , the difference between the post-test and pre-test scores for the self-regulation skills of each student in the experimental and control research groups was felt, and the arithmetic mean and standard deviation of the team scores for each group were extracted, and the t-test was applied to two independent samples and the results were included in the following table:

Table (2) The results of the T-test of two independent samples for the development of self-regulation skills for research eye students

variable	Group	No.	Mean difference (Maths.)	Standard deviation of difference	T value		Calculated T value	Sig
					F	Sig		
Developing self-regulation skills	Experimental	67	5.223	8.337	0.566	0.453	426.	0.671
	regulator	64	4.609	8.177				

It is clear from the previous table that the experimental and control groups are heterogeneous in self-regulation at each level of self-regulation because the probability function sig of the Levin test (0.453) is less than the moral value ($\alpha = 0.05$). It is also clear that the moral value (Sig) of the self-regulation skills amounted to (0.671), which is greater than the level of significance ($\alpha = 0.05$). Thus, the second zero hypothesis is accepted and the alternative is rejected. This indicates that there is no statistically significant difference in the development of self-regulation skills between the students of the experimental and control groups. The reason is likely that both strategies used with the experimental and control groups have significantly affected the development of self-regulation skills according to the activities that the subject school was keen to provide and follow up on the duties and activities provided to students. In contrast, the researchers find that there was no statistically significant effect for the students of the experimental group compared to the control, perhaps because of the short period of time in which the experiment was applied. Twelve lessons were not enough to show the effectiveness of the experimental strategy in self-regulation skills

To achieve the second hypothesis, the arithmetic mean and standard deviation of the experimental group scores for the teams of the scale of pre and post self-regulation skills were calculated, and then the T-test was applied to two interrelated samples of the experimental group and the results were included in the following table:

Table (3) Results of the T-test of two interrelated samples of self-regulation skills of the experimental group

variable	Group	No.	Arithmetic mean	Standard deviation of difference	Average of my calculation for the difference	Calculated T-value	Intangible value Sig
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Developing self-regulation skills	Pre-experimental	67	93.313	5.223	8.337	5.129	zero
	Post Experimental		98.537				

The table shows that the value of the probability function (Sig) for self-regulation skills reached zero, which is less than the level of significance ($\alpha = 0.05$) and thus rejects this hypothesis, and this indicates a statistically significant difference in the development of self-regulation skills for the students of the experimental group between the pre and post applications and in favor of the post-test, and this result agreed with the study of both Al-Hajari (2021) and Al-Si D (2020).

The reason for this is likely to be the procedures followed with the students of the experimental group who are accustomed to using the skills of planning, objective setting, self-monitoring, self-assessment, the skill of controlling external stimuli, and the skill of self-enhancement in completing discussions positively with each other and stayed away from the state of inertia and reliability in the implementation of tasks. The stages of presenting the proposed teaching strategies have taken into account the type of academic content and the strategy of divergent thinking appropriate to it. This has led to the diversity of the presentation of the study material in front of students, and thus the focus was on the problem and discussed individually or collectively, as well as focusing on the evaluation mechanism within the same lesson, in addition to the tasks that were given to students within the classroom and even outside it helped to use communication skills with the subject and make associations and inferences, which was reflected in the growth of self-organization of the students of the experimental group.

Fourth: Conclusions: In light of the results of this research, we have concluded the following:

- 1-The possibility of integrating strategies of divergent thinking into the content of the complex analysis material.
- 2-The effectiveness of the teaching strategy according to the strategies of divergent thinking in the development of self-regulation skills.
- 3- This strategy contributed to helping the students of the fourth stage of the Department of Mathematics to learn new experimental methods that facilitate them to understand the topics of the subject of Complex analysis, as well as this strategy can be used by teachers in teaching the subject of Complex analysis in the fourth stage in the faculties of education in the light of the available possibilities.

Fourth :Recommendations: In the light of the research results that have been reached, the researchers recommend the following:

- 1.Holding training courses on teaching mathematics on teaching methods supported by "divergent thinking" strategies, as they proved effective in the educational process within the limits of the current experience.
2. Attention to educational methods and activities in accordance with this strategy, which stimulates understanding and understanding of the relationships and mathematical links between different topics and linking them to the reality of the situation.

Fifth: Proposals: The researchers propose to conduct studies on :

- 1- The effectiveness of using strategies of divergent thinking in teaching numerical analysis in achievement and developing reflective thinking skills among students of the Department of Mathematics.
- 2-The effect of the use of divergent thinking strategies on the development of analytical thinking skills among fourth-grade students.
- 3- The effectiveness of strategies of thinking in the development of the achievement of mathematical statistics for the fourth stage among students of the Department of Mathematics.

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