International Journal of Learning, Teaching and Educational Research
Vol. 19, No. 10, pp. 77-99, October 2020
https://doi.org/10.26803/ijlter.19.10.5

Effect of Differentiated Instruction on the Achievement and Development of Critical Thinking Skills among Sixth-Grade Science Students

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Abstract. The objective of this study was to explore the effect of using a differentiated instruction method on the achievement and development of critical thinking skills among sixth-grade students in Abha, Saudi Arabia. The study used the experimental method through the application of the instructional program on a sample of 50 students, who were chosen purposefully from one school in Abha city. The sample was divided into an experimental group (n = 25), which received instructions using differentiated instruction, and a control group (n = 25), which received instructions using conventional methods. Two tests were developed, an academic achievement test and a critical thinking test, to measure the performance of students before and after using the instructional program. Findings showed an improvement in the academic performance of the experimental group, which were taught using the instructional program based on differentiated instruction. Participants were able to increase their level of critical thinking skills in science. The study recommends using this instructional strategy in different school subjects other than science. The study also recommends training teachers on its implementation in classrooms.

Keywords: differentiated instruction; academic performance; critical thinking; science subject

1. Introduction

Each classroom has students at different levels in terms of previous experiences, background knowledge, learning methods, needs, tendencies, and interests. Using one method in teaching without responding to the differences between students may not bring out the desired results. This may result in neglecting essential segments of the classroom and in failure to meet students' needs and diversifying the outputs. Low achievers may not find support and help to overcome the educational process and address their deficiencies. At the same

time, outstanding students will not find new materials to enrich their skills and experiences or even to develop them (Al-Tuwairqi, 2013).

Increasing students' interaction with their peers must go beyond the traditional methods that create a negative role from students. Instead, educators should work on creating a better learning environment by utilizing modern methods that increase interaction and students' ability to think, and involve them in obtaining knowledge, making conclusions, and developing positive relationships between students themselves. Such a procedure should also stimulate their potentials in being more creative. The big role relies on the teacher, as the teacher is one of the sources of the students' motivation. Students have different levels and types of intelligence, learning styles, interests, tendencies, aptitudes, and cultures, and this puts the educational process before a significant challenge to meet their different needs (Abu Jadu & Nawfal, 2010).

There is a need to understand students' learning styles, which is increasingly important in light of the call for group learning within the heterogeneous classroom. The teacher's responsibility here is to ensure that students absorb and engage in learning while identifying their preferred methods. The teacher should help and encourage students to learn while considering their preferred learning style (Al-Rashud & Nawfal, 2017). Based on these needs, the concept of differentiated instruction emerged in the educational field.

1.1. Differentiated instruction

Differentiated instruction aims at utilizing the abilities and skills of every student in the learning process. Additionally, differentiation techniques can be achieved through various activities when teachers use it as a philosophy in the classroom. Teachers are supposed to benefit from effective practices in response to the diverse needs of students (Subban, 2007). This practical definition of differentiated instruction reflects the sociocultural theory of Vygotsky that lies in the social and interactive teacher-student relationship. Diversified education also provides an effective way to address disparity and differences between students. Differentiated instruction is the recognition of students' different backgrounds, aptitude levels, languages, interests, and learning profiles (Subban, 2007).

In the process of using differentiated teaching, the teacher provides specific ways to teach each student according to their particular needs through employing different teaching strategies flexibly. Because differentiated instruction is drawn from theories of multiple intelligences and cooperative learning, it provides an appropriate educational environment through its diverse methods, instructions, and activities. Thus, students achieve the required goals with the method, tools, and activities that suit them (Fadel, 2018; Hakami & Al-Amarin, 2015). This approach urges the teacher to exert the maximum of their practices and teaching methods to meet students' needs to achieve the goals of learning (Muhammad, 2013). This type of education forms a philosophy or a method of thinking about teaching and learning through flexibility in setting learning objectives, presenting scientific content, providing a wide range of teaching strategies, and planning educational activities that are centered around the student (Hassanein, 2016). To achieve the main objectives of this method,

teachers need to take into account students' knowledge, preferences, and capabilities, and how they are organized for learning (Ismajli & Imami-Morina, 2018).

1.2. Principles of differentiated instruction

Differentiated instruction stems from Vygotsky's social and cultural philosophy and his most important views. One of his basic ideas is that learners differ from each other in terms of characteristics, tendencies, home environment, previous knowledge, and learning styles and that each student has a mentality different from his classmates, as they learn in different ways and at different times. In addition, this theory provides methods, procedures, and activities that enable each student to achieve the required goals using the appropriate method and tools, and provides a suitable learning environment for all learners (Al-Jamal, 2019). This kind of education also believes that feelings, emotions, and passions affect the learning process as well (Al-Tuwairqi, 2013).

The main pillars of differentiated instruction are the teacher and the student, where the teacher is the coordinator and facilitator of the teaching process and the student is the recipient of the educational process. The teacher has a clear idea of the subject matter, and takes into account, appreciates, and builds upon the differences between students. The teacher also modifies content, processes, and product in response to the students' aptitudes, tendencies, and attitudes, and according to the appropriate teaching style. One of the principles of differentiated instruction is the positive and active participation of all students in an environment characterized by mutual respect, where the student and teacher collaborate in learning and work together flexibly (Tomlinson, 2005).

1.3. Objectives and importance of differentiated instruction

Differentiated instruction seeks to achieve several goals, including the provision of flexible approaches in content, processes, and outputs (Heacox, 2012). It also seeks to develop educational activities based on critical topics, concepts, processes, and essential skills, as well as on multiple methods of presenting the learning process. This kind of education takes into account students' readiness levels, their teaching needs and interests, and the details of the learning process. It provides opportunities for students to work according to different teaching methods and agrees with curriculum standards and requirements for each student. In general, differentiated instruction aims at creating classrooms that include the responding student and the teacher-facilitator of the learning process (Abu Qabytah, 2013).

There are several justifications to apply differentiated instruction in education. It helps the teacher to see students according to the differences and variations among them. High-achieving students have needs, demands, and interests in the same way as students who face learning difficulties. Therefore, differentiated instruction focuses on using modern teaching techniques through the diversification of teaching methods to help all students of different levels to achieve maximum levels of excellence in the light of their abilities (Fadel, 2018; Hakami & Al-Amari, 2015). Eventually, students' self-confidence increases, and

the level of motivation for students to complete educational tasks successfully is more enhanced (Abdulqader, 2019).

1.4. Critical Thinking

Critical thinking is one of the topics that educators are interested in because of its importance in empowering students with essential skills during the educational process. Part of this interest in critical thinking is evident in the tendency of educators of all scientific positions to adopt strategies for teaching and learning critical thinking skills (Abu Jadu & Nawfal, 2010). The definitions of critical thinking have varied due to the different theoretical perspectives of researchers. John Dewey made the first attempts to define critical thinking, where he argued that it is part of the contemplative thinking of the individual's ability to be active and persistent. He also believed that it is cautious thinking that deals with studying and analyzing beliefs and what is expected of knowledge based on the real ground, supported by the ability to deduce. On the other hand, Sternberg linked critical thinking with the ability to solve problems, as he defined it as mental processes and strategies that the individual uses to solve problems. Tishman, Parkins, and Sternberg believed that critical thinking directs individuals' minds to produce innovative results, decisions, and solutions to various issues (Al-Shamlati, 2015).

Abu Jadu and Nawfal (2010) defined critical thinking as reflective, inferential, self-evaluative thinking that includes a set of interconnected cognitive strategies and processes such as interpretation, analysis, evaluation, and making conclusions to examine opinions, beliefs, evidence, concepts, and claims. They argued that these processes are relied upon when issuing a judgment, solving a problem, or making a decision, taking into account the views of others. Al-Jaber (2016) defined it as a group of mental practices that lies in the process of interaction between the individual and the different educational situations.

Critical thinking is of great importance in education for both teachers and students. It improves teachers' ability to teach and produce valuable and responsible practical achievements. It also helps teachers to create activities that allow their students to practice these skills in the classroom. Conversely, it helps in developing students' ability to be objective and adhere to clarity and accuracy. Critical thinking also improves students' achievement in various school subjects by allowing them to practice a wide range of thinking skills. It urges students to observe and control their thinking, which helps them in making important decisions (Abu Jadu & Nawfal, 2010). Using critical thinking skills encourages teachers in creating situations to elevate students' interest by focusing on open questions, encouraging classroom discussions, respecting the opinion of colleagues, listening to others' points of view, and providing the opportunity for all students to express their opinions (Al-yarbou, 2017). Critical thinking includes several central skills that need to be worked on. Peter Facione (2007) classified them into six skills: interpretation, analysis, evaluation, deduction, explanation, and finally, self-organization. Saadeh (2011) believed critical thinking skills to include induction, deduction, comparison, classification, evaluation, priority setting, and unification of the links between relationship,

cause and effect, analysis, succession, recognition of views, and analysis of arguments.

1.5. Previous studies

Several studies have been conducted on differentiated instruction. Magableh and Abdullah (2020) investigated the impact of using differentiated instruction strategies in improving the academic achievements of students in the English language. The study was applied to 60 students from the eighth grade, who were selected randomly from two schools in Jordan. The sample was divided into two groups. The control group (n = 30) learned English using the traditional method, whereas the experimental group (n = 30) learned using the differentiated instruction methods. The study tested participants' performance before and after applying the experiment. The results revealed that differentiated instruction had a great impact on the performance of the experimental group in learning English language skills.

Dack (2019) collected data from 250 teachers working in the education field on the role of differentiated instruction. The study collected data through desk review, assignments, observations, and interviews. The interviews consisted of ten questions and the observations were done in the classrooms. The results revealed that a better understanding of the role of differentiated learning helps teachers and students to achieve better outcomes from the learning process.

Melese and Tinoca (2019) explored the instructor's knowledge, attitudes, and practice of differentiated instruction at Bahir Dar University. The study used the qualitative method. The sample consisted of faculty members. Date were collected through interviews and focus group discussions. The results showed that the attitudes of faculty members were positive towards differentiated instruction. The results also revealed that faculty members have a medium level of knowledge on differentiated learning and they do not practice it properly.

Al-Rashud and Nawfal (2017) investigated the effectiveness of a differentiated instruction-based training program in improving the academic achievement of science, self-concept, and parallel thinking among third-grade intermediate students. The instructional program was developed to include the dimensions of differentiated education, which is to modify the content according to the differentiation of students and to integrate parallel thinking skills. The study used the achievement test, the self-concept scale, and the parallel thinking scale to test a sample consisting of 59 students. The results revealed the existence of differences due to the application of the training program in favor of the experimental group on the achievement test, the self-concept scale, and the parallel thinking scale.

Muhammad (2017) identified the effect of a proposed unit in science based on differentiated education to teach scientific concepts and scientific sense to second-grade students. The study relied on descriptive, analytical, and quasi-experimental approaches. The study sample consisted of 44 students. The results of the study indicated that teaching the unit using differentiated education developed students' awareness of relationships, knowledge, and scientific

concepts. Students received organized knowledge while their learning styles, abilities, and interests were kept in consideration.

Al-Rashidi (2015) identified the effectiveness of differentiated education in improving levels of primary stage deaf students' motivation towards learning science. The study used a quasi-experimental method. The study sample (20 students) was divided into one experimental and one control group. The results of the study indicated that teaching according to differentiated instruction improved the level of motivation towards science learning among deaf students, as well as the existing differences between the level of the deaf students in the experimental group on the scale of motivation towards learning science as a whole.

Hakami and Al-Amarin (2015) investigated the degree of applying differentiated education for science teachers among their students during classroom teaching in Syria. The researchers built a questionnaire consisting of 30 items on the practice of science teachers for differentiated education, and it was applied to 125 science teachers. The results revealed that the level of practicing differentiated education by science teachers was very low. The results also showed no differences because of the gender variable. As for the experience variable, there were significant differences in favor of less-experienced teachers as opposed to those with higher educational qualifications.

Al-Mahdawi (2014) identified the impact of differentiated teaching on academic achievement in the biology course of secondary students. The study sample consisted of 45 students. The results of the study showed that the students who received training through differentiated teaching performed better than the students in the control group in the achievement test.

Abu Qabytah (2013) explored the impact of using differentiated education on acquiring scientific concepts and increasing tenth-grade students' motivation towards learning science. The study was applied to a sample of 136 tenth-grade students in two schools, chosen purposefully. The results found differences in the scores of students in the test of acquiring scientific concepts and test of motivation towards science due to the teaching strategy. Female students achieved better scores than male students in both tests.

Kinsberg (2012) examined the effects of differentiated education in teaching geology for sixth graders through three lessons within one unit of study. The study used the survey method, interviews, and teacher observations as tools to collect data. The results showed that there was an impact on student achievement, participation, and attitudes. Detailed instructions improved achievement for low-achieving students, whereas the results for other students were mixed. Students had more negative attitudes. After applying differentiated instruction, this experiment yielded mixed effects on student and teacher engagement.

1.6. The problem of the study

There is an urgent need to accomplish the objectives of any designed curriculum and the principles of equal educational opportunities among students in the

education process. Students' motivation to learn must also be increased, while taking into account students' needs, preferences, previous experiences, and their differences in skills, interests, abilities, and intelligence capabilities. We find in the real application that science teachers mostly focus on middle-level students, without taking into account the high and low achievers. Different studies and research (Al-Qahtani, 2013; Al-Shahrani, 2016; Al-yarbou, 2017) have raised the importance of differentiated instruction. Therefore, science teachers must adapt teaching methods based on their knowledge of students' abilities and mental capabilities and their levels of growth and achievement. They should also pay attention to students' scientific, economic, and social backgrounds, as well as possess knowledge of their attitudes, tendencies, and values. Science teachers rely heavily on the teacher's guide and curriculum, which leads to lower quality in teaching and fewer outcomes.

Teaching methods vary according to students' academic levels and abilities. Therefore, choosing methods should suit student needs that stimulate their motivations towards learning and which are in a manner consistent with the nature of the material presented to them. The science subject can be presented in more than one advanced way to achieve the desired goals. The researcher noticed, during his visit to schools in Aseer educational region, as a supervisor of field education specializing in elementary education, the frequent complaints of many science teachers about the difficulty of teaching developed science curricula. Most of the teachers use conventional methods without activating the student's role due to their lack of familiarity with modern techniques.

Therefore, the study raised the following question:

- What is the effect of teaching science using differentiated instruction on the achievement and development of critical thinking skills among sixth-grade students?

This main question has two sub-questions:

1- What is the effect of teaching science using differentiated instruction in developing the academic achievement of sixth-grade students?
2- What is the effect of teaching science using differentiated instruction in developing the critical thinking skills of sixth-grade students?

The importance of the current study lies in the fact that it aims to improve students' performance in their academic achievement and to develop their critical thinking skills in science. The study raises and directs attention to the importance of addressing modern topics related to science education. It also raises the issue of the importance of preparing teachers and developing their teaching methods, in addition to developing the teaching performance of teachers through the use of modern techniques.

2. Methodology

The study followed the quasi-experimental approach. The study sample was divided into two groups: a control group, which studied the unit on space using the conventional method, and an experimental group, which studied the space unit using differentiated instruction. The variable of the study was an

independent variable, which was represented in the method of teaching and has two levels: differentiated instruction and the conventional method. The dependent variable was represented in the participants' responses to the academic achievement test and the critical thinking test.

2.1. Sampling

The study population included sixth-grade students who studied science in Abha during the 2019/2020 academic year. The sample included 50 male students from the sixth grade who were studying science at Habib bin Zaid Elementary School in Abha. The school was chosen purposefully due to the cooperation of the principal and its teachers and the availability of the necessary facilities to conduct the study. As for the two study groups, one experimental and one control, they were divided randomly into two equal groups.

2.2. Instrumentation

The following instruments were used to answer the questions of the study:

Frist: the academic achievement test

This test was designed to measure students' achievement in science before and after the experiment according to Bloom's levels for academic achievement. It was built according to the following procedures:

1. Space unit content analysis and formulation of behavioral goals spread across Bloom's cognitive levels.
2. Preparing a table of specifications for the test, taking into account the relative weights of the content dimensions and the levels of behavioral goals.
3. Writing the test paragraphs of the multiple-choice type. Their final number were 20 paragraphs.
4. The content analysis, behavioral objectives, and test items were presented to the judges, where they were asked to review the content analysis, test items, alternatives provided for each paragraph, and linguistic accuracy.
5. In light of the opinions of the judges, the test was finalized and applied to an exploratory sample outside the study sample to ensure its reliability and to calculate the discrimination and difficulty coefficients.

Validity of the achievement test

The validity of the achievement test was tested by presenting it to a group of eight judges who are experts and specialists in science teaching methods. The judges provided comments on the correctness of alternatives and the accuracy of the language. In light of the judges' comments and suggestions, some adjustments were made to the test.

The discrimination coefficients were calculated using the following equation:

Eqn 1:

$$\text{Discrimination coefficient} = \frac{\text{Number of correct answers for the upper group} - \text{number of correct answers for the lower group}}{\text{Number of students in one group}}$$

The discriminations coefficients for the test items ranged between 0.30 and 0.81, which are acceptable rates.

The difficulty coefficients were calculated using the following equation:

Eqn 2:

$$\text{Difficulty coefficients} = \frac{\text{Number of errors in the questions}}{\text{Number of participants}}$$

The difficulty coefficients for the test items ranged between 0.28 and 0.77, which are acceptable rates.

Reliability of the achievement test

The reliability of the test was ensured using the test re-test method. The test first was distributed to a sample consisting of 20 students other than the study sample, and was then re-applied after two weeks. The stability coefficient was calculated and was 0.89, which is suitable for the study, and thus the test was put in its final form (see Appendix 1).

Second: the critical thinking test

This test was designed to measure the extent to which sixth-grade students acquire critical thinking skills in science before and after experimenting with five skills: interpretation, deduction, comparison, classification, and evaluation of arguments. It was developed based on the following steps:

1. Identifying the test objective to measure the critical thinking skills of sixth-grade students in its five dimensions. The test items were distributed on these dimensions.
2. The test items were as follows:
    - Explanation skill, consisting of three questions, including 12 paragraphs.
    - Deduction skill, consisting of three questions, including 12 paragraphs.
    - Comparison skill, consisting of three questions, including 12 paragraphs.
    - Classification skill, consisting of three questions, including 4 paragraphs.
    - Evaluating arguments, consisting of three questions, including 8 paragraphs.
3. The number of test items were 48 divided into 15 questions (see Appendix 2).

Validity of the critical thinking test

The critical thinking test was presented to eight judges who are experts in curriculum design and teaching methods to consider the suitability of the test. They checked the test in terms of the correctness of the language and suitability for the study. In light of their comments and suggestions, some modifications were made.

Reliability of the critical thinking test

The test re-test method was used to check the reliability of the critical thinking test. An exploratory sample (n = 20) from outside the study sample was tested, who received the test again after two weeks. The reliability coefficient of the test was 0.89 (see Appendix 2).

2.3. The educational material

The educational material focused on the space unit, which was prepared to suit the nature of differentiated instruction to be a guide for science teachers to use during preparation and application. The following are the steps for preparing the educational material:

1. Analyzing the space unit content and setting behavioral goals for each lesson.
2. Developing a daily preparation plan for each lesson according to the differentiated instruction (think-pair-share/brainstorming/cooperative learning).
3. Presenting the preparation plans to a group of eight judges to express their observations and opinions. Amendments were made from deletion and addition according to their observations.
4. The material was ready for implementation in the classroom on the experimental group, and was then presented to the teachers participating in the experiment, who trained to implement it.

2.4. Procedures

The following steps were applied to implement the study:

1. Reviewing the literature and previous studies related to recent trends in science education, in particular the use of differentiated instruction that is suitable for the age characteristics of sixth-grade students.
2. Reformulating the lessons of the space unit according to differentiated instruction and presenting them to a group of judges and to make adjustments according to their opinions and observations.
3. Preparing two study tools (achievement test and critical thinking test) in the subject of science.
4. Choosing the school of the study – Habib bin Zaid Elementary School in Abha – in a purposeful manner. The experimental and control study groups were divided randomly. The experimental group received instructions using differentiated learning, whereas the control group received instructions using the conventional method.
5. Identifying the time for conducting the study. It took three weeks to execute the study.
6. Applying the pre-achievement and pre-critical thinking tests before conducting the study to the two study groups to assess the level of sixth-grade students in critical thinking and achievement in science.
7. Teaching the reformulated space unit using differentiated instruction to the experimental group, and teaching the control group the same unit using the conventional method.
8. Applying the post-achievement and post-critical thinking tests to the two study groups to assess the level of sixth-grade students in critical thinking and achievement in science.

9. Correcting the two tests, recording their results, and conducting appropriate statistical analyses using SPSS to extract data for discussion.
10. Discussing the results and coming up with recommendations.

2.5. Data Analysis:

To answer the study questions, statistical analysis was done by extracting standard deviations and mean scores of participants' responses to the achievement test and the critical thinking test. The t-test was used to answer the study's questions related to the detection of any statistical differences between the two groups according to their scores in the post-achievement and the post-critical thinking tests.

3. Results and discussion

3.1. Results before applying the study

To ensure levels of the experimental and control groups were equal, the achievement test and the critical thinking test were applied to the two study groups before experimentation. Table 1 shows the extracted mean scores and standard deviations of the responses to the academic achievement test.

Table 1. t-test results for the responses of the two study groups to the pre-achievement test

Variable	Group	No.	Mean score	St. dev	t-value	Sig.
Pre-test	Control	25	14.52	3.5356	0.824	Not statistically significant
	Experimental	25	15.04	2.1213		
	Total	50				

Table 1 shows that there were no significant differences in the overall mean scores for both the control (M = 14.52, SD = 3.5356) as well as the experimental group (M = 15.04, SD = 2.1213). After conducting the t-test, the t-value was 0.824, which is not statistically significant (at $\alpha = 0.05$). Therefore, there was an absence of statistical differences between the two groups, which means that the two groups learned on approximately the same level.

Table 2. t-test results for the responses of the two study groups to the pre-critical thinking test

Variable	Group	No.	Mean score	St. dev	t-value	Sig.
Pre-test	Control	25	14.88	3.6778	1.1157	Not statistically significant
	Experimental	25	13.68	3.9234		
	Total	50				

Table 2 shows that there were no differences in the overall mean scores for both the control (M = 14.88, SD = 3.6778) as well as the experimental group (M = 13.68, SD = 3.9234). The t-value at 1.1157 is not statistically significant (at $\alpha = 0.05$). This indicates that there are no statistically significant differences in the scores of the two groups, which means that the two groups learned on approximately the same level.

3.2. Results of the first question

The first research question was: What is the effect of teaching science using differentiated instruction in developing the academic achievement of sixth-grade students?

The mean scores and standard deviations of the participants' responses to the post-achievement test were extracted as shown in Table 3.

Table 3. t-test results for the responses of the two study groups to the post-achievement test

Teaching method	No.	Mean score	St. dev	t-value	Sig.
Experimental (differentiated instruction)	25	17.04	1.4854	5.0104	Significant (at $\alpha = 0.05$)
Control (conventional method)	25	14.16	2.461		
Total	50				

Table 3 shows that the calculated t-value was 5.0104, which is statistically significant (at $\alpha = 0.05$). This shows the existence of statistical differences between the mean score of the control and experimental groups. The experimental group outperformed the control group after having studied science using differentiated instruction. The mean score of the control group was 14.16, with a standard deviation of 2.461. This indicates the usefulness of using differentiated instruction in teaching science to the sixth grade. The reason for the better achievement of the experimental group could be attributed to the nature of differentiated instruction and its appropriateness to the science subject.

The unit from the science curriculum was from newly developed material focusing on contemplating space and linking it to cosmic phenomena that students see in reality. Some cosmic phenomena require deduction, knowledge, and application in reality. Using this teaching method provided participants the desire to think, expand their knowledge, conclude, and link the information contained therein. In addition, the diversity of the differentiated instruction patterns was to facilitate the process of understanding information, assimilating it, and then recalling and remembering it by all participants. This was demonstrated through participants' interaction and responses during the experiment, which facilitated the acquisition and retention of scientific materials and experiences and their transfer to similar new educational situations. They also developed their self-dependence in answering and correcting themselves when wrong and enriching their information when incomplete.

3.3. Results of the second question

The second research question was: What is the effect of teaching science using differentiated instruction in developing the critical thinking skills of sixth-grade students?

The mean scores and standard deviations of the participants' responses to the post-critical thinking test were extracted as shown in Table 4.

Table 4. t-test results for the responses of the two study groups to the post-critical thinking test

Teaching method	No.	Mean score	St. dev	t-value	Sig.
Experimental (differentiated instruction)	25	29.68	9.37959	5.65022	Significant (at $\alpha = 0.05$)
Control (conventional method)	25	24.64	10.5154		
Total	50				

Table 4 shows that the t-value was 5.65022, which indicates the existence of statistically significant differences (at $\alpha = 0.05$) in the mean scores of the control and experimental groups. The scores of the experimental group that studied using differentiated instruction were better. The mean score of the control group that studied in the conventional method was 24.64, with a standard deviation of 10.5154, which the experimental group performed more superiorly in the post-test.

This may be attributed to the great compatibility between differentiated education styles used (brainstorming, cooperative learning, and think-pair-share) and between critical thinking and its relationship with the science subject of space. This enabled the participants to practice various mental skills while applying the study, raising different discussions and expressing opinions, organizing ideas, and allowing them to meditate and think. It also provided participants the chance to link ideas and topics with each other, which helps in developing critical thinking skills. Using this strategy enabled all participants to delve into the sciences because this strategy is built on respect for students' minds and potentials and encourages them to present their ideas and opinions, listen to their colleagues, and discuss with them, thereby enriching them with multiple critical thinking skills.

4. Conclusion

The effect of using differentiated instruction in teaching science to sixth-grade students in Abha, Saudi Arabia was investigated in this study. The researcher developed training material based on the differentiation strategy. The participating students received the training and were tested afterward. The results of the study revealed an improvement in the academic level of the experimental group after being taught using the differentiation strategy. This indicates the effectiveness of this strategy and its appropriateness to be used in classrooms, not only in science classes, but also in other subjects.

4.1. Recommendations

The study recommends extending the application of differentiated instruction to include the rest of the branches of science curricula in other educational levels.

Teachers of science need to receive training on how to use differentiated instruction in teaching because of the positive impact on academic achievement and the development of critical thinking skills. It is important also to identify the effectiveness of using differentiated teaching in other learning outcomes such as creative thinking, reflective thinking, and attitudes towards the school subjects. The study also recommends applying differentiated instruction to a larger sample or another sample of middle and high school students, or a sample of female students, or a sample from other educational areas.

4.2. Limitations of the study

Thematic limitations: the study was limited to the Space Unit from the textbook of the sixth grade, edition 2019. The study focused on measuring the impact of differentiated instruction strategy on academic achievement according to Bloom's levels. The critical thinking test was limited to the following skills: interpretation, deduction, comparison, classification, and evaluation of arguments. Human limitations: The study was conducted on a sample of sixth-grade male students from Habib bin Zaid Elementary School in Abha. Time limitations: The study was conducted in the second semester of the 2019/2020 academic year.

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Appendix 1

The academic achievement test

1. The apparent motion of the sun is caused by: A. Earths circulation around its orbit B. The succession of the seasons C. Earth's rotation around the sun D. Earth's axis.
2. The longitude that shows the change in dates is called: A. Baseline latitude B. International dateline C. Equator D. Standard time zone
3. The rotation of the earth around itself results in: A. The succession of night and day B. Solar eclipse C. Lunar eclipse D. Phases of the moon
4. The craters on the surface of the moon, which are in the form of deep plates, are called: A. Lunar seas B. Moon phase C. Nozzles D. The sun and the stars
5. The tide is a phenomenon that arises due to the force of attraction between: A. Earth and the Moon B. The Sun and Earth C. The Sun and the stars D. The ocean and land
6. Earth’s rotation around the sun is: A. The annual Earth cycle B. The earth’s monthly cycle C. Tides D. Gravity
7. The main reason for the occurrence of the four seasons is: A. The angle of inclination of the Earth's axis changes as it orbits around the sun. B. The angle of inclination of the Earth's axis changes as it orbits around the moon C. The distance of Earth from the sun changed during its orbit around the sun D. Earth's circulation around its orbit.
8. Which of the following is not a galaxy form: A. Spiral B. Irregular C. Elliptical D. Square

9. One of the following happens to the universe from the moment of the Big Bang until today:
   A. Overheating
   B. Contraction
   C. Expansion
   D. Explosion
10. The color.....indicates a greater surface temperature of the star:
   A. red
   B. yellow
   C. Bluish white
   D. Orange
11. The Milky Way galaxy is:
   A. Primitive galaxy
   B. An irregular galaxy
   C. Elliptical galaxy
   D. Spiral galaxy.
12. Astronomers call the small rocky bodies that collide with the surface of the moon as:
   A. Meteors
   B. Moons
   C. Meteorites
   D. Comets
13. Which of the following planets is closer to the size of the Earth:
   A. Mercury
   B. Mars
   C. Venus
   D. Jupiter
14. The suitable unit for measuring distances between stars:
   A. meter
   B. kilometer
   C. mile
   D. light year
15. A planet that can have rings is:
   A. Mercury
   B. Saturn
   C. Neptune
   D. Venus
16. What separates the inner and outer planets of the solar system is:
   A. Asteroids belt
   B. Meteors and meteorites belt
   C. Stars
   D. An Atmosphere
17. If it is seven o'clock in the evening in Riyadh, then the time in Marrakesh is:
   A. 10 pm
   B. 4 pm
   C. 7 pm
   D. 6 pm

18. Sundial is:
    A. A simple tool to tell time using shadow length and direction
    B. A tool for measuring the distance between Earth and the sun
    C. A tool for measuring the length of the tides
    D. Standard timing instrument

19. The width of the standard time zone is:
    A. 15 degrees between the meridians of Earth
    B. 15 degrees between latitudes on Earth
    C. 24 degrees between the meridians of Earth
    D. 20 degrees between latitudes of Earth

20. The "large group of stars that are bound together by gravity" is called:
    A. Nebula
    B. galaxy
    C. comet
    D. Meteorite

Appendix 2

The critical thinking skills test

Interpretation skill

- Place (√) in the box you consider the right answer:
- Some phrases may have more than one result, and you must specify them all.

1. If you travel west of the International Date Line, what happens?

No.	Interpretation	Consequential	Not Consequential
1	Delay in time		
2	Advance in time		
3	Time stays as it is		

2. Earth is the only planet suitable for life.

No.	Interpretation	Consequential	Not Consequential
1	For the presence of water and air		
2	There is a life that we do not know about on other planets		
3	For its distance from the sun		
4	Because of gravity		

3. There are no crater edges on the moon's surface:

No.	Interpretation	Consequential	Not Consequential
1	Because of the ongoing erosion processes		
2	There is no life on the moon		
3	There is no water or air on the surface of the moon		
4	Space objects collide with the moon		
5	Spaceships land on the surface of the moon		

Deduction skill

- This test includes phrases followed by several conclusions that may be correct or wrong. You are required to read the phrase well and then read the conclusions resulting from it, and then put (√) in the box representing your answer.

1- A lunar eclipse occurs when:

No.	Suggested conclusions	Right	Wrong
1	Earth passes in the moon's shadow		
2	Earth is located between the sun and the moon		
3	The sun is between Earth and the moon		
4	The sun passes in the shadow of the moon		

2- Tide happens because of:

No.	Suggested conclusions	Right	Wrong
1	Gravity between Earth and the moon		
2	Gravity between the sun and the moon		
3	solar eclipse		
4	Lunar eclipse		

3- What happens because of the moon's rotation around the earth?

No.	Suggested conclusions	Right	Wrong
1	The tides		
2	Moon phases		
3	A succession of the four seasons		
4	a succession of night and day		

Comparison of skill

- The following phrases and concepts have a commonality in a certain meaning. Identify what is unique about each concept and write it down in the space provided.

1. Concept one: Earth
   Concept two: the Moon

1	What is common between the two concepts?	
2	What is unique in the first concept?	
3	What is unique in the second concept?	

2. Concept one: Meteor
   Concept two: Comet

1	What is common between the two concepts?	
2	What is unique in the first concept?	
3	What is unique in the second concept?	

3. Concept one: Annual Earth Cycle
   Concept two: Daily Earth Cycle

1	What is common between the two concepts?	
2	What is unique in the first concept?	
3	What is unique in the second concept?	

4. Concept one: Spiral galaxy
   Concept two: irregular galaxy

1	What is common between the two concepts?	
2	What is unique in the first concept?	
3	What is unique in the second concept?	

Classification skill
This test includes lists of vocabulary, each list has one characteristic except for one vocabulary between that does not belong to the group. You are required to read the vocabulary lists, and then identify the different vocabulary and write it in the space provided.

1. Which of the following is different from the others?

List	**Different vocabulary**
Sun - Mercury - Venus - Mars	

2.

List	**Different vocabulary**
Phases of the moon - lunar eclipse - craters - solar eclipse	

3.

List	**Different vocabulary**
Asteroid - comet - meteor - light year	

4.

List	**Different vocabulary**
Reflecting astronomical telescope - sundial - refracting astronomical telescope	

Evaluation of arguments:

The following are a set of issues related to the science course. Each case was placed in a special table and followed by four arguments, some of them are strong and some of them are weak. Place (√) in front of the argument that represents your answer.

1. We cannot live without stars:

No.	Evaluation of argument	Strong	Weak
1	They help in setting directions		
2	They decorate the sky		
3	They light the universe		
4	They help in identifying seasons		

2. We cannot live on Mercury because:

No.	Evaluation of argument	Strong	Weak
1	Very high temperature		
2	Very low temperature		
3	No gravity		
4	No water on the planet		