



Abstract. Encouraging students' higher-order thinking skills (HOTS) has become an ultimate objective for several education programmes. Being a significant domain of scaffolding strategies, HOTS has been considered as a concern that should persistently be at the vanguard of reform agenda of science. The present research aims to examine the effect of scaffolding strategies on HOTS of middle school science students in the context of Saudi Arabia. To carry out the research aim, quasi-experimental design has been applied based on multiple-choice questions comprising 20 questions all distributed on four skills, namely, application, analysis, evaluation and creation. The total population of the research was 84 grade 9 students who all sat for both pre-test and post-test. Convenient sampling was chosen as a sampling method that typically suits both the experimental group (42 students) and the control group (42 students). After collection, data were analysed using both descriptive analysis, mean and standard deviation, and inferential statistics including t-test, one-way analysis of variance (ANOVA) and multivariate ANOVA. The effect of scaffolding strategies on the four skills was found to be significant ($p < .01$). The present research can contribute to the enhancement of students' HOTS, provided that scaffolding strategies are applied in science classes and, from a research perspective, will be a reference for researchers who are interested in scaffolding strategies in the context of either Saudi Arabia or other countries.

Keywords: higher-order thinking skills, Saudi Arabia, scaffolding strategies, science education

Khaled Saleh Alrawili, Kamisah Osman
National University of Malaysia, Malaysia
Saeed Almontasheri
Albaha University, Saudi Arabia

EFFECT OF SCAFFOLDING STRATEGIES ON HIGHER-ORDER THINKING SKILLS IN SCIENCE CLASSROOM

**Khaled Saleh Alrawili,
Kamisah Osman,
Saeed Almontasheri**

Introduction

For decades, education reformation has become a global concern, where several reports have been made regarding the first tier of reforms, especially those in Australia, Europe and North America. Nevertheless, there is still insufficient amount of information available on the second stage of reforms, particularly those in Africa, Asia, Eastern Europe and Middle East (Alghamdi & Al-Salouli, 2013). Saudi educators have considered the King Abdullah Public Education Development Project, also known as the 'Tatweer' education reforms, to be an important phase in enhancing the quality of teaching and learning within the kingdom (Tayan, 2017). It was believed that this educational reform could contribute to the development of the new generations of Saudis, preparing them for the economic well-being of the nation. Consequently, since 2008, the Kingdom of Saudi Arabia has been prioritising the improvement of the kingdom's educational infrastructure, with the ultimate goal of promoting the reformation of both school and curriculum (Alghamdi & Al-Salouli, 2013). Because of the necessity of developing the teaching-learning content, in 2009, new curricula were introduced by the Ministry of Education (MoE) based on student-centred learning and conceptual understanding rather than memorising information, as well as the need for meaningful connections to students' lives and experiences. These new curricula are the greatest positive indication that the MoE has recognised the need to meet international standards and encourage students more actively in their learning.

Nevertheless, there is still a substantial amount of work to be done. To work towards the curricula and teaching development, the MoE has spent billions of dollars to develop the curriculum in general and science in particular. The project focused on four areas, namely, the development of educational curricula, the teachers training, the improvement of classroom activities and the improvement of the educational environment. The plan was to accomplish the design of the project within 6 years, but the project did not make the deadline; none of the four featured areas achieved the ultimate goal. An additional 6 years may be required to complete the project (Almannie, 2015). To address this problem, more emphasis should be given on the teaching approaches that can help implement the new curriculum

objectives such as higher-order thinking skills (HOTs) for which the current research is focused (Ah Nam & Osman, 2015; Azevedo, 2005; Quintana et al., 2005).

Scaffolding is often formulated to develop HOTs and to maximise the use of students' mind (Newmann, 1991) who can enhance their HOTs by participating actively in learning activities such as making hypotheses, generating arguments and gathering evidence. As essential for the learning process, thinking skills interrelate the ability to complete a given task with cognitive processes (Milvain, 2008). This might lead to the importance of HOTs as the highest level in the hierarchical control of cognitive processes. According to Yee et al. (2015), HOTs are developed when new information is gained or retained, compiled and linked to existing knowledge. Then, HOTs are used aiming to solve a complicated situation (Zohar & Dori, 2003). It has also been observed that teachers have positive attitudes towards instruction using HOTs; this is one of the reasons that motivated the researchers to conduct the present study.

Bloom's taxonomy and scaffolding devices are two faces of the same coin—both aim to improve HOTs. When teaching, teachers' ultimate objective is to allow students to accomplish tasks that are assumed to be beyond their students' ability. Hence, the teachers' role is to assist and guide them, and this assistance can be realised through an instruction device that provides students with required intellectual support that functions as a cutting edge of these students' cognitive development. This educational goal can be achieved through the scaffolding process. As students need their teachers' help to develop the idea of learning, they can, at the same time, realise, identify and raise their ideas and questions because of the suitable environment that surrounds them (Tortop, 2013). In other words, students would have an initial picture as they become familiar with the phenomenon. Hence, the significance of scaffolding application lies in the fact of providing a positive influence on students' achievement because it assists them in formulating relevant hypotheses during learning processes (Dasilva et al., 2019). The significance of the present research comes through understanding the importance of HOTs that have become one of the top priorities in education in general and have been incorporated into the revised science curriculum in particular. To find good thinkers instead of mere learners, HOTs is now applied to cover different aspects of learning including definitions, calculation, facts, vocabulary and many other fundamental skills in scientific explorations.

In the 1960s, the second half of the last century, Saudi Arabia public school was established and considered attendance for children as mandatory. Gender segregation is a norm in many Middle East countries; Saudi Arabia, where girls and boys attend school separately from grades 1 to 12, tops this list. The same goes with teachers, in which female teachers for female students and male teachers for male students. The educational system in Saudi Arabia is organised into three levels, namely, elementary school from grades 1 to 6, secondary school from grades 7 to 9 and high school from grades 10 to 12 (Clark, 2012).

As has been mentioned earlier, Saudi Arabia government has a strong motivation to develop and reform the curriculum of science shifting towards standardisations. This is reflected through the country repeated participations in the Trends in International Mathematics and Science Study (TIMSS) where the kingdom participated four times between 2003 and 2019. Despite these efforts to develop science curricula, the results were not satisfactory and the curriculum of science is not changed neither in teaching methods nor in the ways of students' thinking because of their attitudes towards science subject (Alanazi, 2017; Alqifari, 2020). As confirmed by the report prepared by the Excellence Research Center of Science and Mathematics Education, the development of science education in Saudi Arabia in the TIMSS 2019 was significantly below the international test standards. This reveals the need to conduct follow-up studies to monitor the levels of science content coverage that need to be provided to students for improvement and development (Alqifari, 2020; Alrweili & Alanazi, 2018).

HOTs can be considered as important aspects in teaching and learning. As thinking skills are fundamental in educational process, a person's thought can affect the ability, speed and effectiveness of learning, which is why thinking skills are associated with learning process where students with HOTs can learn, improve their performance and reduce their weaknesses (Arsad & Osman, 2019; Sunaryo et al, 2020; Yee et al., 2015). According to King et al. (2013), HOTs are the ability to think that requires not only the ability to remember but also higher capabilities to deal with unfamiliar problems, uncertainties, questions or dilemmas. Hence, HOTs can be used to predict the success of students, and learners who have good levels of HOTs are expected to succeed in their studies later.

In the context of Saudi Arabia, science students are not often exposed to HOTs, which leads to severe consequences that ultimately lead to poor achievement in science subject. It has been argued that teachers in Saudi Arabia start their teaching in class with no appropriate pedagogical preparation (Alghamdi, 2018). Consequently, they most probably lack effective teaching skills despite being knowledgeable in their discipline. Hence, the significance of research lies in the fact that it comes to enhance the basic skills necessary to communicate science



teachers' knowledge to their students. Therefore, inside the classroom, teachers can take the class time as an advantage to educationally express their idea and thus to enhance HOTS that lead to collaborative learning and can provide various student-centred activities. To achieve that, policy makers, administrators, instructors and all other stakeholders need to "create a learning environment that allows students to deepen subject content knowledge and practice various 21st century skills in real situations, hence produce students who have a strong foundation of science knowledge and design process, as well as able to work and communicate effectively in groups to generate innovations" (Ah-Nam & Osman, 2017, p.214).

Based on constructivism theory, the conceptual framework of the research has been determined to be applied on the experimental group that was taught using scaffolding strategies that rely on 5Es model. The reason for choosing 5Es model is that it is rich in terms of offering strategies and ways that can assist students to be successful, who are the main focus in the class and not their teacher whose role is just to guide when necessary. The 5Es model has been applied because of its relevance as an instructional model that has emerged from the constructivism theory that states that learners should construct new ideas on top of their old ideas. Another significant point is that the 5Es model is suitable for students of all stages including middle school students. Furthermore, the 5Es model provides opportunities for both teachers and learners to use and build on prior knowledge and to experience common activities, and it continuously allows them to evaluate their understanding of the concepts learned. Being eclectically bound to Bloom's taxonomy and as a constructivist model of learning, the 5Es method includes five stages, namely, engagement, exploration, explanation, extension and evaluation. Being the core of scaffolding strategies, HOTS constituted the conceptual framework of the present research where the four skills of HOTS, namely, application, analysis, evaluation and creation have been thoroughly investigated. As has been mentioned above, the processes of HOTS always refer to the skills that are of cognitive nature including applying, analysing, evaluating and creating (Nachiappan et al, 2018). This cognitive nature of HOTS makes it the most suitable platform for carrying out the present research. Therefore, the present research provided an answer for the questions 'how do scaffolding strategies improve students' HOTS in science?' In implementing the research question, it was hypothesised that there is no statistically significant difference in the mean between students taught using the combined module of scaffolding and those taught using traditional teaching methods with respect to HOTS.

Research Methodology

General Background

The present research was based on quasi-experimental design research in which the course is viewed as an 'intervention' where a treatment comprising the elements of the course is evaluated and tested. The present research design reflects how well it achieves the research objectives, as measured by a pre-specified set of indicators (Fraenkel & Wallen, 1996). The quasi-experimental approach was used to answer the research question (how do scaffolding strategies improve students' HOTS in science?) and examine the effect of the use of educational scaffolding strategies on HOTS among science students enrolled in the 9th grade of the Middle school in Saudi Arabia. The science topic used in the intervention is the 2nd Chapter (Earth Changes) of science syllabus prescribed for the grade 9 Saudi Middle school students. The same topic was taught for both the experiential group, using scaffolding strategies that focus on the HOTS, and the control group using conventional method. Table 1 summarises the design of the research.

Table 1
Research design

Group	Pre-test	Treatment	Post-test
EG	HOTs	Hybrid SS & 5Es	HOTs
CG	HOTs	Conventional	HOTs

As shown in Table 1, EG refers to experimental group taught using scaffolding techniques based on 5Es model and CG refers to control group taught using traditional science instruction. Here, HOTS refers to higher-order thinking skills. SS refers to scaffolding strategies, and 5Es, instructional model. Before teaching, a test was administered



to both experimental and control groups to determine students' prior knowledge and experiences on HOTS in a science unit. After the treatment, the post-test was administered to compare the effectiveness of SS and 5Es with conventional approach on students' HOTS.

In minimising the threats to internal and external validity of the research, three main elements were considered. The first is the selection of groups where only the grade 9 male students and only one chapter (entitled Earth Changes) was selected from the science course of grade 9. This may limit threats of the external validity compared with the rest of the chapters of science syllabus standards and to generalise the results on female students. The second is the differences between the experimental group and control group focusing both equality between them as well as the drop-out rate that, if happened, can harmfully affect the experimental group due to inequality. The third element is the interaction and maturation of the selected groups and their appropriateness for measuring the experimental variables (Shadish et al., 2002).

Additionally, because of time constrains, the length of the research was limited to approximately 12 lessons. It could be argued that a longer application period might be more advantageous to allow more time for evaluating the effects of the scaffolding strategies, which require richer materials and research. As a research that applies quasi-experimental for data analysis, it becomes more possible that internal validity could be the main limitation because of the nature of this technique, in which accuracy is more sensitive because the treatment and control groups may not be comparable at baseline. Considering such threats, random assignment technique was applied where the classes were chosen randomly and had the same chance in terms of the intervention group and the comparison group of the research.

Research Setting and Sampling

The present research was conducted among Grade 9 (upper secondary) male science students in one of the Saudi public middle schools located in Arar city. This school was selected because of the variety of students' backgrounds who come from different parts of Saudi Arabia, and this gives the research more authenticity. The population in the present research was grade 9 students from a school that ranked the first in the area (Saeed Bin Al-Musayeb School). It is also a government Middle School for Boys, and the research was carried out in the academic year 2019–2020. Creswell (2012) assured that majority of the research studies in the area of education are conducted with the underlying objective of gathering information pertaining to the characteristics of the total population. Generally, population is made up of the combination of the various elements that share similar characteristics. Conversely, it is the subgroup or a part of the total population, which is, in turn, assumed to represent the entire population in a particular research endeavour. Gratton and Jones (2010) stated that since researchers cannot collect data from the entire population, data are generally collected from samples that are representative of the entire population.

Considering this important issue, the population of the present research comprises grade 9 Saudi male science students. The required data were collected using the convenient sampling technique. For measuring the effects of SS on Saudi male students' HOTS, self-administered questionnaires were distributed among the conveniently selected grade 9 male science students. Chronologically, students were closed in age between 14 and 15 years. The total number of students involved in the present research was 84 divided into two equal groups (EG and CG), 42 students for each. This study followed the ethical guidelines provided by The National University of Malaysia Human Research Ethics Committee. Proper permissions were obtained from all the respondents and from the school in which the study was conducted. Additionally, students were informed that these tests would be used for research purpose only and would never be seen or used by their teachers.

Research Instruments

The research instrument was the questionnaire that was constructed based on four categories all related to HOTS, namely, application, analysis, evaluation and creation. The questionnaire comprises 20 items, and all were of multiple-choice questions assigned with four distracters (a, b, c and d). The questionnaire was validated by three experts who majored in HOTS science education. The questionnaire was conducted after piloting and considering the experts' suggestions to develop the questionnaire. Reliability was examined using Kuder and Richardson test, which reveals an internal consistency of .80.

The reason of considering the above-mentioned four skills is to contribute on enhancing students' HOTS. Ac-



ording to Ngah et al. (2017), HOTS have always been an essential demand of the 21st education, and it has been increasingly discussed in the educational literature. Considering this significance, the present research views HOTS as a current educational approach that involves a complex thought process that focuses on thinking rather than just memorising facts or repeating such facts to teachers. In other words, in HOTS, the focus is not only on understanding the facts but also on linking them with other relevant facts and reusing them to solve new problems encountered. In this way, HOTS can be used as a pedagogical tool for encouraging students' higher cognitive levels that come as a result of the obtained experience gained from learner-centred environment.

Data Analysis

Prior to carrying out any statistical analyses, such as correlation, it is necessary to ensure that any assumptions made for a test are not violated. Testing of assumptions usually involves getting descriptive statistics on the variables. These descriptive statistics include the mean, standard deviation, range of scores, skewness and kurtosis (Pallant, 2000). Furthermore, independent sample *t*-test (Sekaran, 2003) was used to explore the differences between two groups such as groups. These tests were used because the present research needs to compare the mean scores. Additionally, paired sample *t*-test (Samuels & Gilchrist, 2020) was used to compare the means of data from two related samples. However, paired sample *t*-test was used because the present research needs to compare the mean. Relatively, to determine whether there are differences in the means of a continuous dependent variable across a set of two, one-way analysis of variance (ANOVA) test was run. The purpose of ANOVA is to confirm any differences among the means of two groups (DeCoster, 2006) because if the ANOVA test is significant, it indicated that the groups have means that are significantly different from each other.

Regarding the HOTS test duration, the researchers calculated the answer duration taken by the slowest student on the test and added it to the answer duration of the fastest student and then divided the total by (2).

$$TD = \frac{L+F}{2},$$

where TD = test duration, L = slowest student's answer duration and F = fastest student's answer duration. Consequently, the appropriate time needed to answer the HOTS test was 35 min. After the researchers were sure of the validity and reliability of the test, and according to the opinions of the peer reviewers and the specialists, the test came into existence in its final form.

Statistical analysis has acute sensitivity to non-normality and as such, a basic data assumption is the examination of the causal structure among the variables of the research where data skewness and kurtosis are used to confirm normality of data (Tabachnick & Fidell, 2001). Particularly, skewness range of acceptability is between ± 3.00 , whereas kurtosis range of acceptability is 7.00 revealing that data measurements had normality with all the skewness and kurtosis statistics within the range of +1.96–1.96.

Research Results

Prior to moving on with the testing of the hypothesis (i.e. there is no statistically significant difference in the mean between students taught by the combined module of scaffolding and those taught using traditional teaching methods with respect to HOTS), the research conducted independent sample *t*-test and ANOVA on the independent samples in order to identify whether the groups are statistically equivalent and homogenous. The research dependent variables include the four elements of HOTS, and the results indicated no significant differences in the variables homogenous test. In the initial analysis set, the difference, if any, between the two groups (experimental and control groups) were determined in terms of application, analysis, evaluation and creation based on .05 significance level. First, the independent sample *t*-test was carried out to evaluate the differences between means for the two groups in pre-test and post-test for the skills. ANOVA and multivariate ANOVA (MANOVA) also were carried out to compare the differences between means for the two groups on pre-test and post-test.

The reason for conducting ANOVA and MANOVA is to determine whether a significant difference in the pre-test score for dependent variables exists between groups. ANOVA is usually applied when more than two groups are being considered and tests whether their population means are equal. Furthermore, it is essential to select ANOVA when subscales are used because subscale are composite scores. Furthermore, MANOVA might be an appropriate way to analyse statistical significance among several dependent variables that might vary between groups.



Independent sample *t*-test, ANOVA and MANOVA for independent samples were completed before testing the research hypotheses for the purpose of determining whether the two groups are statistically equivalent prior to the start of the experiment. The dependent variable is HOTs. The first set of statistical tests was conducted in order to ascertain the differences between the experimental and control groups in pre-test HOTs based on the .05 level of significance. However, the results of independent sample *t*-test results showed that there was no significant difference found between the two groups considering pre-test scores of students' HOTs. More inspection was conducted using ANOVA test, and the results of ANOVA in Table 2 indicated that there are no significant differences between the groups in the pre-test scores of HOTs ($MS = 25.190$, $F = 1.727$, $p = .192$).

Table 2

Results of ANOVA for between-subjects effects of the research variable Pre-test

Source	Dependent variables total pre-test	Sum of squares	df	Mean square	F	p
Between group		25.190	1	25.190		
Within group	HOTs	1196.048	82	14.586	1.727	.192
Total		1221.238	83			

* $p < .05$

MANOVA with the dependent variable of HOTs in pre-test is analysed. The assumptions of multivariate normality and homogeneity of variance-covariance are conducted, and all of the assumptions are met as shown in Table 3, which indicates that the data achieved the homogeneity test and there are no significant differences between the two groups on pre-test of HOTs ($MS = 25.190$, $F = 1.727$, $p = .192$). These findings reveal that, as there are no significant differences in the mean of the pre-test results, there is a high equivalence between the two groups in terms of number and academic background.

Table 3

Results of MANOVA for between-subjects effects of the research variables Pre-test

Source	Dependent variables total pre-test	Type III sum of squares	df	Mean square	F	p
Corrected model		25.190	1	25.190	1.727	.192
Intercept		8560.762	1	8560.76	586.91	.000
Group	HOTs	25.190	1	25.190	1.727	.192
Total		9782.00	84			

* $p < .05$

The pre-test mean score of HOTs for the sample was ($M = 10.09$, $SD = 3.83$), with a mean post-test score of ($M = 10.54$, $SD = 3.76$). The groups scored individual different scores for the pre-test, with the experimental group scoring ($M = 10.64$, $SD = 3.91$) in HOTs pre-test compared with the control group that scored ($M = 9.54$, $SD = 3.71$). In the post-test, the experimental group scored higher in HOTs ($M = 11.50$, $SD = 3.63$) compared with the control group ($M = 9.59$, $SD = 3.69$), according to the module time presented in Table 4. The results come in line with the research conducted by Alsowat (2016), who reported that there were statistically significant differences between the mean scores of the two groups in the HOTS test in terms of analysing, evaluating and creating with a 'total grade of ($t = 11.909$, $p < .001$) in favour of the experimental group, which meant that the experimental group outperformed the control group significantly at $p < .001$ ' ($p.116$).



Table 4*Summary statistics for HOTs scores (N = 84)*

Variable			Total sample	Experimental group	Control group
HOTs	Pre-test	Mean	10.09	10.64	9.54
		SD	3.83	3.91	3.71
	Post-test	Mean	10.58	11.50	9.59
		SD	3.793	3.63	3.69

Based on null hypothesis, there is no statistically significant difference in the mean between students taught using the combined module of scaffolding and those taught using traditional teaching methods with respect to HOTs. For this purpose, independent sample *t*-test was carried out to test the difference between the two groups post-test considering HOTs, and the result supported significant differences where ($F = .004$, $p = .949$, $t = 2.380$, $p = .020 < .05$) for experimental group.

Furthermore, the ANOVA analysis was carried out with the HOTs variable in the experimental and control groups, with the first set of analysis producing significant main effects and statistical significance between the scores of the two groups in terms of HOTs ($MS = 76.190$, $F = 5.666$, $p = .020$) as shown in Table 5.

Table 5*Results of ANOVA for between-Subjects Effect of the HOTs Post-test*

Source	Sum of squares	df	Mean Square	F	p
Between group	76.190	1	76.190		
Within group	1102.619	82	13.447	5.666	.020
Total	1178.810	83			

* $p < .05$

It was concluded that a significant difference existed in the mean score in the application and evaluation subscales regarding the post-test of the two groups. The students in the experimental group reported higher application mean score ($M = 3.92$, $SD = 1.19$) than their counterparts ($M = 2.80$, $SD = 1.56$), and students in the experimental group reported higher evaluation mean score ($M = 2.57$, $SD = 1.65$) than their counterparts ($M = 1.76$, $SD = 1.60$). Despite the insignificant results for analysis and creation subscales, the mean and standard deviation values, presented in Table 6, showed that students in the experimental group had higher mean analysis scores ($M = 2.78$, $SD = 1.53$) than students in the control group ($M = 2.21$, $SD = 1.84$). However, for creation, no significant difference was found, and the scores of both groups were almost the same where the students' scores in the experimental group reached a mean of 2.19 with a standard deviation of 1.79, compared with those in the control group ($M = 2.21$, $SD = 1.84$).

Table 6*Summary Statistics for Variables Post-test Scores (N = 84)*

Variable		Experimental	Control
Application	Mean	3.92	2.80
	SD	1.19	1.56
Analysis	Mean	2.78	2.21
	SD	1.53	1.84



Variable		Experimental	Control
Evaluation	Mean	2.57	1.76
	SD	1.65	1.60
Creation	Mean	2.19	2.21
	SD	1.79	1.84

More inspection was carried out on the HOTS subscales results. Paired samples *t*-test was carried out to measure the increase of mean score in the HOTS subscales. The first HOTS subscale is application, which shows significant results in the experimental group. As shown in Table 7, the experimental group overall application scale pre-test mean score was $M = 3.73$, $SD = 1.30$, and post-test mean score was $M = 3.92$, $SD = 1.19$. Therefore, the mean score was increased according to the experiment given to students.

The second HOTS subscale (i.e. analysis) was insignificant in the experimental group. The experimental group overall analysis subscale scale pre-test mean score was $M = 2.71$, $SD = 1.61$, and post-test mean score was $M = 2.78$, $SD = 1.53$. Conversely, the third HOTS subscale (evaluation) was significant in the experimental group where the experimental group overall evaluation subscale of pre-test mean score was $M = 2.14$, $SD = 1.76$, and post-test mean score was $M = 2.57$, $SD = 1.65$. As shown in Table 7, the fourth HOTS subscale (creation) was significant in the experimental group where the experimental group overall creation subscale of pre-test mean score was $M = 2.04$, $SD = 1.78$, and post-test mean score was $M = 2.19$, $SD = 1.79$.

Table 7

Summary Statistics for the Experimental Group Subscale Scores

Variable		Post-test	Pre-test
Application	Mean	3.92	3.73
	SD	1.19	1.30
Analysis	Mean	2.78	2.71
	SD	1.53	1.61
Evaluation	Mean	2.57	2.14
	SD	1.65	1.76
Creation	Mean	2.19	2.04
	SD	1.79	1.78

When the overall mean score was compared by paired sample *t*-test, application was found significant at $t = -3.106$, $df = 41$, $p = .003$. Furthermore, as shown in Table 8, there was a significant increase ($p < .05$) in the experimental group mean in students' subscale.

Table 8

Results of Paired Sample *T*-test for Variable

	Variable	<i>t</i>	<i>df</i>	<i>p</i>
Experimental group	Application	-3.106	41	.003
	Analysis	1.776	41	.083
	Evaluation	-3.949	41	.001
	Creation	-2.011	41	.051

When the overall mean score was compared by paired sample *t*-test, it was found insignificant at $t = 1.776$, $df = 41$, $p = .083$. Furthermore, when the overall mean score was compared by paired sample *t*-test, it was found



insignificant at $t = -3.949$, $df = 41$, $p = .000$. When the overall mean score was compared by paired sample t-test, it was found insignificant at $t = -2.011$, $df = 41$, $p = .051$.

Discussion

The findings of the research reveal that students were highly motivated to attain content taught using scaffolding strategies. In a similar vein, teachers were observed reforming their teaching strategies that cope with enhancing HOTS, and they were able to engage the students by providing attractive and interesting activities. The class seemed to be learner-centred, and teachers have a minor role, whose part was just to guide students when necessary. Such teaching strategies were found to be helpful in enhancing the students' HOTS and thus promote their learning skills (Lee & Osman, 2014). The research findings come in line with Mehmood et al. (2017) in finding out that the systematic use of combined teaching strategies efficiently enhanced students' HOTS through challenging them to take lessons actively. It is also important to mention here that after conducting the treatment, the students of the experimental group attained higher marks than their counterparts in the conventional group. This proves that, to gain better performance, students need to develop not only their lower-order thinking skills but also their HOTS. This supports the claim of Osman and Marimuthu (2010) and recently Yuliati and Lestari (2018), who stated that learners can survive in today's challenging by using their HOTS.

The importance of scaffolding emerges from its ability to help students realise learning and then assist them to experience the skill of thinking. Scaffolding strategies are normally applied in the light of selecting appropriate tasks that meet the ultimate objectives of the curriculum and the needs of students. In this way, it could be argued that scaffolding strategies have the potential to develop students' commitment towards learning and motivate them forward because of providing them with prompt questions, stories, models, hints and many other visual scaffolding strategies including representational gestures and other approaches of highlighting visual information (Alibali, 2006). Furthermore, scaffolding always focuses on monitoring students' progress through feedback considering that they have accomplished the content assigned and they are aware of their progress. Being at the top of HOTS, scaffolding pays enough attention to 'creation' by providing a supportive learning environment that works on encouraging students to try alternatives and to take risks based on their thoughts, experience and knowledge (Birjandi & Jazebi, 2014).

Furthermore, the results of the research come in line with the research conducted by Lee and Kamarudin (2014) revealing that most of the teachers viewed that using HOTS, as an 'inquiry-based pedagogy', would lead to promoting students in different educational aspects such as confidence that plays a vital role in their participation. This due to providing chances for students to learn from each other and allowing them to explore on their own with a typical understanding of the values of social interaction that enhance learning based on constructivism, the typical approach for learning science. Consequently, the research found that supporting a creative teaching and learning process especially in science seems to be influential and a significant factor in school to promote productivity and creativity especially in the classroom teaching-learning processes. The research results support Arase et al. (2016) and Vejian et al. (2016), who suggested that creative school climate would cultivate creative behaviour and interactive work among school stakeholders including teachers and learners. The research results prove the claim by Tsapalis (2020), which states that several education processes are required to enhance science students' HOTS.

What could be argued here is that, in the present research, no significant difference was found in terms of creation and the scores of both the experimental and conventional groups were almost the same. The reason for this might be due to the time constrain where students need longer time to develop their skill of creation as this skill needs longer time for engaging students to deal with a more complex and challenging tasks that need deep conceptual understanding. According to researchers, students often have difficulty in accomplishing HOTS, especially the creation skill, as it takes considerable effort and time to engage students in the learning process (Bransford et al, 2000; Marin & Halpern, 2011). The importance of students' HOTS development lies in training them to think critically and creatively. From the results of the research, it could be elicited that HOTS can equip students with the ability to overcome problems with the use of mental act by which acquiring knowledge becomes more affordable.

To put it in a nutshell, the present research reveals that there is a noticeable improvement in students' understanding, and this improvement indicates that establishing a HOTS-based teaching-learning environment in Saudi schools to cope with the requirements of the 21st century is important. Scaffolding enhances the collaborative effort through the teacher-learner interaction within classroom learning. Furthermore, learners are given an active role that is necessary for them to become self-regulated, in which the main focus is given to learners through



their educational engagement and reaction in classroom activities. As an assistant or a guide, the teacher's role in the classroom is to direct learners to activities on their own and to provide answers to their questions besides discovering the understanding of what is being taught. This comes in line with the viewpoint of Verenikina (2008), who stated that a task can be learned by a child independently when given a chance by an adult, and this is the main goal of scaffolding, which fosters learner-centred classes.

Conclusions

The focus of the present research is on the existing concepts, thoughts, practices, approaches and strategies with respect to the art of teaching using scaffolding strategies in the context of science education. The present research mainly aimed to examine the effect of scaffolding on developing HOTS of Saudi middle school science students. Four HOTS have been precisely scrutinised in Saudi context, namely, application, analysis, evaluation and creation, all eclectically bound with teaching–learning science. Based on the results of the research, teachers should be encouraged to reduce teacher-dominated learning and pay more efforts in adopting scaffolding strategies that give the main role for learners to establish student-centred learning environment. Inspired by the research findings, both administrators and instructors need to involve learners in learning situations that enhance their HOTS. The results of the present research contribute to the body of knowledge in evaluating students' HOTS in science learning as shown in the evaluation of HOTS among grade 9 students in Arar city, Saudi Arabia.

The present research has been carried out in male middle school, and it could be expanded to include female schools to scrutinise the effect of scaffolding on students' HOTS in terms of gender. Despite the significant improvement in the students in the experimental group compared with those in the control group, a longer period of time could have proven a greater influence of scaffolding on learners. Furthermore, tape-recorded semi-structured interviews, with both students and teachers, could have provided more detailed and rigorous qualitative data as a greater chance could have been provided for participants to share more information when talking than when writing. Based on that, it could be recommended that future science education research on HOTS can take longer time (i.e. a semester or full school year) to consistently measure more improved results. The added value of the present research reveals the need for the contribution of the education process to develop students' HOTS in science learning. Specifically, the present research has supported the view that the students should be driven to use thinking strategies through scaffolding techniques and real-life issues rather than blind memorisation of texts and algorithms. The research findings are expected to be beneficial for teachers, curriculum designers and researchers interested in HOTS and science education. Finally, the current research is proposed to be a landmark for future work on scaffolding strategies with respect to HOTS to find out their effect on teaching–learning processes of various subjects in different contexts.

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Khaled Saleh Alrawili

Master's in Education (Science Education), PhD candidate, Faculty of Education, National University of Malaysia (Universiti Kebangsaan Malaysia), 43600 UKM Bangi, Selangor, Malaysia.
E-mail: kh333k@hotmail.com, P93621@siswa.ukm.edu.my
ORCID: <https://orcid.org/0000-0001-9320-7817>

Kamisah Osman
(Corresponding author)

PhD in Science Education, Professor, Centre of Research on Teaching and Learning Innovation, Faculty of Education, National University of Malaysia (Universiti Kebangsaan Malaysia), 43600 UKM Bangi, Selangor, Malaysia.
E-mail: kamisah@ukm.edu.my
ORCID: <http://orcid.org/0000-0003-4734-8031>

Saeed Almontasheri

PhD in Science Education, Assistant Professor, Faculty of Education, University of Albaha, Albaha, Saudi Arabia.
E-mail: Saeedalmontasheri@gmail.com
Website: <https://bu.edu.sa>

