The Effectiveness of a Constructive Learning Approach in Acquiring Science Processes and Developing Thinking Skills: A Meta-Analysis Study By

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Abstract

The research aimed to investigate the results of previous studies that investigated the effectiveness of a constructive learning approach in acquiring science processes and developing thinking skills. The research employed the descriptive method using the meta-analysis method, for the studies conducted at (2010-2020). The study sample consisted of (95) studies, distributed over (64) published research studies, (26) MA theses, and (5) PhD dissertations. The effect size means for the studies that addressed acquiring science processes was (3.436), for the development of thinking skills (2.423), and for the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills (together), (3,278) and (2,373), respectively, based on Cohen scale these indicate high levels. The research dealt with the set of variables (educational stage, specialization, study type, sample size, country), they all obtained a significant effect size (High level). The highest effect size registered for the previous research studies of (primary stage, general science, published research studies, medium sample size, Egypt). In light of the results, the study suggest to conduct future research studies define the effectiveness of constructive learning approach at the secondary school and undergraduate stage using a large sample, in various science courses, specifically earth and environmental Sciences.

Key words: Constructive Learning Approach, Acquiring Science Processes, Development of Thinking Skills, Meta-Analysis Study.

Introduction

Constructivism theory has become the prevalent learning theory in most educational systems, used frequently in the teaching process, as it approved its effectiveness in different educational variables; also the curriculum has been designed based on its principles in some of the educational systems.

According to the Constructivist theory, student creates his knowledge through thinking in the interactions and experiences based on real experiences, and this stems from the teachers teaching methods for the learning content and students' learning outcomes. Constructive approach confirms that learners must participate effectively in all the teaching processes from the beginning to the end, and that real life activities is the best method for applying

constructivist classes and critical thinking, also it organize lessons based on the learner needs and interests to create a motivational educational structure that focuses on the effort and the thinking of the learner instead of focusing on the teacher (Csizmadia, Standl & Waite, 2019).

Constructivism has the advantage of making the learner the center of the learning process and developing his positive attitude toward science. It also gives the learner the opportunity to think and practice the basic and integrated processes of science, enhance his ability to apply knowledge in the different contexts, and this was confirmed by The National Science Teaching Association (NSTA) to create an educated learner (Zaitoon, 2017).

Science processes and the different thinking skills are considered a main objective of teaching science; they help the learners to transfer learning experiences to other contexts, develop their abilities to discover and innovate, as they include mental skills that scientists and students use to understand the phenomena in the surrounding environment (Khataibeh, 2011).

The strategies based on constructivism theory (e.g. learning cycle, constructivist learning model, problem based learning, etc.) emphasized their effectiveness in acquiring science processes (Abdullah, 2019; Choirunnisa, Prabowo & Suryanti, 2018; Samawy, 2017), and developing the different thinking skills (AL-Hashem, 2019; Althateeri & Abualoum, 2018; Qarareh, 2016).

In view of multiplicity of previous studies in constructive learning and proving its effectiveness, it is important to provide a thorough recommendation confirming that constructive learning strategies are highly effective on various variables such as (Achievement, thinking, science processes, science attitude, etc.). This is done through meta-analysis that combines the results of similar studies that are performed independently and interpreted more consistently, and extrapolate useful generalizations from the data and results and learn about the effectiveness of these research studies. Consequently, it is possible to provide an appropriate decision and design new studies, as it is difficult to conduct a study on large samples due to a set of challenges such as time, cost and researchers availability; in addition, discussing the results of one study is not sufficient to make a general decision appropriate for all variables (Turgut & Turgut, 2018).

Meta-analysis is used to reveal the meaning behind the current research studies and literature, as it enables researchers to define the gaps in the literature, the topics that need more concentration in the future studies, help in sitting the needed guidelines for future research studies, the effective use of existing data, ensure generalization, and to use a clear statistical methods in analyzing data (Gopalakrishnan & Ganeshkumar, 2013).

Meta-analysis depends on different practical significance indicators that are used to detect the magnitude of the relationship between variables such as Eta squared (η), Omega Square (ω), and effect size indicator (Cohen d). Effect size is considered the most appropriate statistical method in meta-analysis research studies, as it has been have been emphasized by American Psychological Association (APA) In light of the fact that statistical significance testing results are influenced by the characteristic of the sample size, and the statistical significant is not considered an appropriate measure to measure the intervention effect, as the increase in the sample size, makes the possibility of rejecting the null hypothesis becomes greater and thus the magnitude of the relationship between the independent and dependent variables is magnified, and this limits the ability to define the magnitude of the real relationship between these variables.

The educational research studies have addressed constructive learning in many meta-analysis studies. For example, Candra and Rentawati (2020) studied the effect of constructive learning on the learning outcomes in physic education, specifically, in students' acquisition of citizenship concepts. Arik and Yilmaz (2020) study examined the effectiveness of constructive learning and active learning on students' environmental education; the effect size was (1.463) which is a significant effect. Balemen & Ozer Keskin (2018) study aimed to reveal the effectiveness of project-based learning in the context of academic performance and various study properties. The study used a sample consisted of (48) research study. The results of the study showed that the general effect size for project-

based learning in teaching science was (1.063), while in physics it was (1.148); chemistry (1.01); biology (1.364), and in science (0.974). According to the educational stage, the effect size for elementary school was (0.964), secondary school (0.909), and undergraduate stage (1.768). While according to the sample size, the effect size of the small sample was (1.231), the medium sample (0.898), and for the big sample it was (1.201). The study showed no statistically significant differences between the effect size means in light of study type, as the effect size means of the published research studies, MA theses, and PhD dissertations were (0.883, 1.049, 1.89) respectively.

Yaman and Karasah (2018) conducted a study to define the effect of learning cycle models (Four stages learning cycle, five stages learning cycle, seven stages learning cycle) on learning science, for the studies conducted in (2004-2016), there were (75) studies. The study found no statistically significant differences between the effect size means due to learning cycle model, study type (Research study = 1.11, MA theses = 1.09, PhD dissertations = 1.44), and study main interest (Physics = 1.28, biology = 1.23, chemistry = 1.11), educational stage (Elementary = 1.49, intermediate = 1.18, secondary = 1.21, undergraduate = 1.17), and sample size (small = 1.15, medium = 1.29, large = 1.43). The effect size means according to the year of the study was (1.18).

In his study, Sarac (2018) examined meta-analysis for a set of research studies examined the effect of using learning cycle models on students' performance and conceptual learning in the period (2007-2016) by using a sample consisted of (35) MA thesis and PhD dissertation. The results showed that effect size means was (1.306), and the highest value for the effect size was for the PhD dissertation (1.434) and MA thesis (1.157). The study found statistically significant differences in the effect size, in favor of biology (1.828), chemistry (1.359), physics (-0.424) respectively, and in favor of secondary school (1.428), elementary school (1.229), intermediate school (1.183), and undergraduate stage (0.948) respectively, while there were no statistically significant differences between the effect size means in light of learning cycle models.

In another study by Cakir (2017) aimed to conduct meta-analysis of the studies that addressed the effectiveness of the 5E's learning cycle model on achievement, trends, and science skills, for studies in the period (2006-2016). The sample of the study consisted of (22) published research studies and (10) PhD dissertations that addressed achievement, (14) published research studies and (7) PhD dissertations that addressed trends, and (5) PhD dissertations that addressed science skills. The effect size means for achievement was (1.268); trends (0.583); and for the science skills (1.669).

While Aktamis, Higde and Ozden (2016) conducted a meta-analysis for the studies that have addressed the effectiveness of inquiry-based learning on achievement, science skills and attitude toward science, for (19) studies conducted in the period (2005-2015). The results of the study showed that the effect size means for achievement was (1.029), (0.742) for science skills, and (0.558) for the attitude toward science.

Balta and Sarac (2016) conducted meta-analysis study for the studies that examined the effectiveness of 7Es learning cycle strategy on learning science through a sample consisted of (24) studies conducted in the period (2003-2016). It was found that the effect size means for the academic achievement was (1.245), and it was for the type of the study (1.165) for the published research studies, (1.307) for MA theses, and (1.277) for PhD dissertations. As for the specialization, effect size means for science was (1.002), biology (1.973), chemistry (2.006), physics (1.150), while for the educational stage it was (0.919), (1.419), (1.351) for the intermediate school, secondary school, and undergraduate stage, respectively.

The study of Ayaz and Sekerci (2015) aimed to conduct meta-analysis for the results of (53) published research studies, PhD dissertation and MA thesis conducted on the period (2003-2014), addressed the effect of constructive learning approach on the academic achievement. The results of meta-analysis found that the effect size means for the academic achievement was (1.156). The effect size means for MA theses was (1.341), published research studies (1.272), and PhD dissertations (0.420), respectively. As for specialization, the effect size means was (1.014) for biology, (1.002) for chemistry, (0.559) for physics, while based on the educational stage, the effect

size means was (0.936) for the elementary school, (0.996) for the intermediate school, for secondary school it was (1.363), and for undergraduate stage it was (2.245). Furthermore, the effect size means of the sample that was greater than (30) was (1.299).

By reviewing previous studies, it can be noted that all meta-analysis studies that addressed constructive learning approach proved its efficiency with a significant effect size means in achievement; science attitude, and science skills. Also, they showed no statistically significant differences in light of some variable (e.g. Study type, specialization, educational stage, sample size), as all the values of the effect size means were large based on Cohen classification. Furthermore, all the previous studies have been conducting in in non-Arab societies and it provided several recommendations, most notably to prove the effectiveness of the constructive learning approach in several variables in science. Thus, it is important to analyze the results of the previous studies in some of the Arabic countries that have addressed the effectiveness of constructive learning approach in learning science in acquiring science processes and developing different thinking skills. As, within the limits of reviewing meta-analysis studies, no study was found that address these variables together.

Problem of the Study

The Arab Library witnesses a significant increase in the number of educational research that examines the impact and effectiveness of one of the constructive learning strategies; made researchers study the same variables with a difference in the results, which may be contradictory to what preceded it, which led the educational scientists to search for the best methods to summarize the research studies and provide a comprehensive recommendation that avoids repetition, and this is what calls for the use of meta-analysis of previous studies.

Furthermore, lots of previous studies that addressed the constructive learning approach differ in their results, thus, cannot be generalized due to the difference in the conditions of the applied research studies (Educational stage, sample size, content…), and this call for a meta-analysis research study shows the conclusion of the previous studies and the accurate meanings of the results, and to define the research gaps in constructive learning to conduct future research. Also, meta-analysis research studies considered one of the rare researches in our Arab world, thus, this research may help decision-makers and researchers to reconsidering the conditions for conducting the constructive learning approach and the appropriate cases for it.

Questions of the Study

The study attempts to answer the following questions:

- What is the number and percentage of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of constructive learning approach in acquiring science processes, and developing thinking skills according to (Educational stage, sample type, statistical test, specialization, study type)?
- What is the effect size means of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of using constructive learning approach in acquiring science processes and developing the different thinking skills according to (Educational stage, specialization, study type)?
- What is the effect size means for the of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills, according to (Sample size, country, and the year of the study)?

Objectives of the Study

The study aims to:

- Reveal the number and percentages of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of the constructive learning approach in acquiring science processes and developing different thinking skills according to (Educational stage, sample type, statistical test, specialization, study type).

- Define the effect size means for the experimental studies conducted in the period (2010-2020), addressed the effectiveness of using constructive learning approach in acquiring science processes and developing the different thinking skills according to (Educational stage, specialization, study type, sample size, country).

Significance of the Study

From theoretical perspective the study stems by conducting a research study that addresses the meta-analysis of a set of previous studies, leads to increase the statistical magnitude by merging a large number of samples and provide the opportunity to reveal the true effect size for a set of PhD dissertations, MA theses, and published research studies in the period (2010-2020).

While the implications of this study, stems from the increase in the number of studies and theses that addresses the effectiveness of the constructive learning approach in different dependent variables, and the paucity of research studies that addressed the compilation and analyzing of their results, which will provide multiple data to help researchers and educational decision-makers in choosing the appropriate teaching strategies based on the educational content, sample, and the conditions of research implementation for the educational stage.

Definition of Terms

Constructive Learning Approach: Constructive learning strategies that are based on the basics of constructivism theory, aims to make the learner the center of the learning process, and to create scientific knowledge through a realistic activities (Zaitoon, 2017). It is defined operationally as a set of strategy, models, or learning cycles that are employed in aim to reveal their effectiveness in acquiring science processes and developing different thinking skills in science.

Science Processes: a set of mental abilities that are necessary to implement the methods of science and thinking correctly, and it include basic science processes and integrated sciences processes (Khataibeh, 2011). It is defined operationally as a set of mental abilities that are addressed in a set of previous studies to define the effectiveness of the constructive learning approach on it.

Thinking Skills: a set of complex cognitive processes that process and analyze information from the surrounding environment, evaluate it, to provide conclusions and make decisions. Thinking has multiple types including critical, creative, and contemplative thinking, each one have a set of skills (Sa'dah, 2015). It is defined operationally as a set of different thinking skills that are addressed in a set of previous studies to define the effectiveness of the constructive learning approach on it.

Meta-Analysis: Glass (1976) defined it as "The analysis of analyses", it is a quantitative method for systematic analysis based on overall effect size index that aims to generalize the results of the research, and does not allow for subjective judgments. It is defined operationally as a method used to generalize the results of a set of studies that addressed the effectiveness of the constructive learning approach on acquiring science processes and developing thinking skills in science, by grouping and analyzing them statistically according to a common scale, estimating the effect size in addition to analyzing the relationship between the effect size and other variables.

Methodology

The study used descriptive approach by using meta-analysis, that is concerned with collecting quantitative data from previous studies related to the research studies objectives and defining the effect size. This type of analysis enables knowing the efficiency of a program, a strategy, or a specific approach. It also uses the effect size in revealing the relationship between variables.

The Study Population and Sample

The study population and sample are consisted of all MA Theses, PhD Dissertations and published research studies in the period (2010-2020) in some Arab countries, that addressed the impact or effectiveness of constructive

learning in acquiring science process and developing various thinking skills; their number reached (95) study: (5) PhD Dissertations, (26) MA Theses, (64) Published research studies.

Instrument of the Study

A coding model has been prepared by referring to a set of previous studies such as Mahassneh (2019), Yaman and Karasah (2018), and Cakir (2017). The model included several sections: Study type, year conducted in, sample size and type, educational stage, specialization (General Science, Biology, Chemistry, Physics, Earth and Environmental Sciences), methodology, statistical data; each study was documented separately based on the research studies criteria that were determined.

Validity and Reliability of the Instrument

The instrument distributed on its preliminary format on (6) experts, (3) specializing in measurement and evaluation, and the others specializing on Science curricula and teaching methods. The experts' remarks were taken into consideration, to prepare the instrument in its final format. In order to ensure the reliability of the analysis process and to ensure the reliability of the coding, another analyst was employed, and criteria for inclusion and exclusion of studies were determined according to the instrument. Kappa Coefficient among the analysts was calculated, which was (0.92).

Procedures of the Study

To achieve the study objectives, the following steps were conducted:

1. Defining the objective of the study: Revealing the effectiveness of the constructive learning approach in acquiring the science processes and developing different thinking skill.
2. Defining the experimental studies and how to obtain them: Several electronic resources were consulted to collect the sample of the study, represented in: The Arabic Database (Dar-Almandumah); the website of Hussein Bin Talal Library in Yarmouk University – Jordan; Google; and various electronic websites for scientific journals. Furthermore, several keywords were used in the research studies such as constructive learning; constructive learning strategy; Constructive learning effectiveness; problem-centered learning; the learning cycle; Wheatly model; Bybee model; Woode model; Zahoric model; concept maps; Vee diagram maps; collaborative learning strategy; generative model; investigation; basic science processes, integrated science processes, and thinking development (innovative, critical, creative, scientific, contemplative, complex, analytical, and visual).
3. Defining the research studies criteria for the investigated experimental studies as follows:

- Time limitations for the researched studies (2010-2020).
- The study should be PhD dissertation, MA thesis, or published research studies in a scientific journal.
- The methodology of the study is an experimental / quasi-experimental approach.
- The study must include one of the following educational stages (elementary, intermediate, secondary, undergraduate).
- The study must include the sample size of the experimental group (Small, medium, large) and how it was chosen (Randomly, purposefully).
- The study should be specialized in one of the science fields (General Science, Biology, Chemistry, Physics, Earth and Environmental Sciences).
- The study must include mean, standard deviation, effect size, type of statistical test, statistical data needed to find the effect size.
- The independent variable (Constructive learning) must be in the experimental group, while traditional learning in the control group.
- The instrument of the study to be a test or scale of science processes, and a test or a scale of one of the different thinking skills.

- The studies geographic area is limited to the Arab world.
- The study must address the effectiveness of constructive learning approach in acquiring science process, or the effectiveness of constructive learning approach in developing the skills of one type of thinking, or both.

4. Collecting the studies for the research studies (MA Theses, PhD Dissertations, Published Research studies) during the period (2010-2020), that include the previous research studies criteria.
5. Entering data to Excel in preparation for coding them and perform the statistical analysis later.

Results and Discussion

First Question: "What is the number and percentage of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of constructive learning approach in acquiring science processes, and developing thinking skills according to (Educational stage, sample type, statistical test, specialization, study type)?"

To answer this question, the studies that addressed the effectiveness of the constructive learning approach effectiveness in acquiring science processes, developing different thinking skills or both, according to the previous variables were identified, as seen in table (1).

Table (1): Distribution of the Experimental Studies Conducted in the Period (2010-2020) addressed in the Study According to the Study Variables

Domain									
	Science Processes			**Thinking Skills**		**Both**			
Variable		**Number**	**%**	**Number**	**%**	**Number**	**%**	**Total**	**%**
Educational stage	**Elementary**	**9**	**27.27**	**14**	**27.45**	**2**	**18.18**	**25**	**26.32**
	Intermediate	**19**	**57.58**	**28**	**54.90**	**8**	**72.73**	**55**	**57.90**
	Secondary	**4**	**12.12**	**7**	**13.73**	**1**	**9.09**	**12**	**12.63**
	Undergraduate	**1**	**3.03**	**2**	**3.92**	**0**	**0.00**	**3**	**3.16**
Sample Type	**Random**	**18**	**54.55**	**24**	**47.06**	**7**	**63.64**	**49**	**51.58**
	Purposeful	**15**	**45.45**	**27**	**52.94**	**4**	**36.36**	**46**	**48.42**
Statistical Test	**T-Test for Independent Samples**	**20**	**60.61**	**32**	**62.75**	**9**	**81.82**	**61**	**64.21**
	T-test for Correlated Samples	**2**	**6.06**	**0**	**0.00**	**0**	**0.00**	**2**	**2.11**
	ANOVA	**1**	**3.03**	**4**	**7.84**	**0**	**0.00**	**5**	**5.26**
	ANCOVA	**10**	**30.30**	**13**	**25.49**	**2**	**18.18**	**25**	**26.32**
	MANCOVA	**0**	**0.00**	**2**	**3.92**	**0**	**0.00**	**2**	**2.11**
Specialization	**General Science**	**23**	**69.70**	**31**	**60.78**	**9**	**81.82**	**63**	**66.32**
	Biology	**2**	**6.06**	**8**	**15.69**	**1**	**9.09**	**11**	**11.58**
	Chemistry	**4**	**12.12**	**2**	**3.92**	**1**	**9.09**	**7**	**7.37**
	Physics	**4**	**12.12**	**9**	**17.65**	**0**	**0**	**13**	**13.68**
	Earth and Environmental Sciences	**0**	**0.00**	**1**	**1.96**	**0**	**0**	**1**	**1.05**
Study Type	**PhD Dissertation**	**3**	**9.09**	**1**	**1.96**	**1**	**9.09**	**5**	**5.26**

MA Thesis	**10**	**30.30**	**12**	**23.53**	**4**	**36.36**	**46**	**27.37**
Published Research Studies	**20**	**60.61**	**38**	**74.51**	**6**	**54.55**	**64**	**67.37**

It can be noted from table (1) that:

According to the educational stage, intermediate school ranked first in the previous studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills with a percentage of (57.90%); then the elementary school with a percentage of (26.32%); secondary school with a percentage of (12.63%); undergraduate stage with a percentage of (3.16%), respectively. This result can be attributed to the researchers' interest in studying the effectiveness of constructive learning approach among intermediate and elementary school, where the students have awareness and interest to learn; in addition to the curricula flexibility and the cooperation of the elementary and middle schools administration with researchers in implementing the study, unlike secondary school where the students are occupied in increasing their academic achievement as the secondary school determine their study path at the university. Furthermore, researchers' reluctance from applying research studies to the undergraduate stage could be attributed to the privacy of university education systems and the nature of the courses. Also, university students may do not have any interest to make a commitment to apply the research studies procedures as they know that it will no effect their grades in the courses, in addition, some faculty members are not convinced of the importance of these research studies for their students.

According to the sample type, random sample got the higher percentage in the addressed research studies with a percentage of (51.58%), followed by purposeful sample with a percentage of (48.42%). The random sampling method provides equal opportunities among respondents and the possibility of generalizing the results, as well as the privacy of these samples in the possibility of applying the research tools.

For the statistical test, T-Test for independent samples ranked first, with a percentage of (64.21%), followed by ANCOVA, with a percentage of (26.32%), then ANOVA with a percentage of (5.26%), while T-Test for correlated samples and MANCOVA ranked last, with an equal percentage of (2.11%). This can be attributed to the fact that T-Test for independent samples is the appropriate statistical test for the experimental research studies implemented on the experimental and control groups in case of parity, as for ANCOVA it can be used to make statistical control when there is no parity between the experimental groups in the pre-test. The low utilization rates of T-Test for correlated samples may be attributed to the unavailability of two groups (Control and experimental), and the use of pre-post-test design for the group where the respondent has two scores on the test. While the low use of MANCOVA test may be due to the fact that the nature of this test requires the presence of more than one dependent variable in the research, which may constitute a burden on the researcher in applying the research. As for the low level of using ANOVA, could be due to the need for three levels of the independent variable and that may also constitute a burden on the researcher in applying the research.

According to specialization, general science ranked first in the studies addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills with a percentage of (66.32%), secondly, physics with a percentage of (13.68%), followed by, biology, with a percentage of (11.58%), then chemistry with a percentage of (7.37%), and finally, earth and environmental sciences with a percentage of (1.05%). This can be attributed to the fact that general science is for the primary and intermediate school, where the researchers can address some units of the curricula when applying their research studies, and this correspondents with the results of the educational stage where the intermediate and primary schools achieved the higher percentages

in research studies implementation. As for the low percentage in the use of physics, it can be attributed to the nature of the curricula that requires a lot of thinking and math skills, and this may constitute a burden on the researcher and the respondent in applying the research and the instrument. The low percentage achieved in biology and chemistry may be attributed to the fact that these two subjects are studied in the secondary school, which is the stage that determines the students' path of the study at the university as mentioned before, and for this reason, they focus more on their academic achievement. While the low percentages of earth and environmental sciences curriculum can be attributed to the fact that secondary school students study this subject, where some students who have an interest in this subject decide to study it (In some of the education systems of the Arab countries), and for this reason, some secondary schools may not include classes that teach this subject.

The results of type of the study showed that published research studies ranked first with the highest percentage (67.37%) in the previous studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills, MA thesis ranked second with a percentage of (27.37%), and finally, PhD dissertation with a percentage of (5.26%). This may be attributed to the number of researchers specialized in curriculum and teaching methods in universities, the educational centers and the Ministry of Education whose number exceeds PhD and MA students; this lead to increase the number of published research studies compared to theses. Furthermore, the acceptance rate of PhD students is lower than the acceptance rate for MA students (in general) in universities.

Second Question: "What is the effect size means of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of using constructive learning approach in acquiring science processes and developing the different thinking skills according to (Educational stage, specialization, study type)?"

To answer this question, the total effect size means was calculated for the studies that addressed the effectiveness of using constructive learning approach in acquiring science processes and developing the different thinking skills in the period (2010-2020), as well as, the effect size for every variable according to (Educational stage, specialization, study type). To classify the studies based on the effect size means, Cohen Scale of effect size was adopted (Cohen, Manion & Morrison, 2007). Table (2) shows the classification of the previous studies according to Cohen's classification.

Table (2): Previous Studies Distribution According to Cohen Scale of Effect Size

Effect size	Level	Science Processes		Thinking Skills		Both*		Total Number	Total %
		Number	%	Number	%	Number	%		
0 ≤ ES ≤ 0.20	Weak	1	3.03	3	5.88	0	0.00	4	4.211
0.21 ≤ ES ≤ 0.50	Simple	4	12.12	5	9.80	0	0.00	9	9.474
0.80 ≤ ES ≤ 0.51	Moderate	0	0.00	5	9.80	1	9.09	6	6.316
0.80 ≤ ES	High	28	84.85	38	74.51	10	90.91	76	80
Total		33	100	51	100	11	100	95	100

*** Previous studies addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills together**

It can be noted from table (2) that the number of studies with a weak effect size in acquiring science processes was one study with a percentage of (3.03%), and the number of the studies addressed thinking skills was (3) studies with a percentage of (5.88%), while there are no studies addressing the acquisition of science processes and developing thinking skills together.

As for the number of the with a simple effect size in acquiring science processes was (4) studies with a percentage of (12.12%), and the number of the studies addressed developing thinking skills was (5) studies with a percentage of (9.80%), while there are no studies addressing the acquisition of science processes and developing thinking skills together.

The results also showed that the number of the studies with a moderate effect size in developing thinking skills was (5) studies with a percentage of (9.80%), and the number of the studies addressed the acquisition of science processes, and developing thinking skills together was one study with a percentage of (9.09%), while there are no studies addressing the effectiveness of constructive learning approach in acquiring science processes.

The number of the studies with a significant effect size in acquiring science processes was (28) studies with a percentage of (84.85%), the number of the studies that addressed developing thinking skills were (28) studies with a percentage of (74.51%), and the number of the studies addressed both variables were (10) studies with a percentage of (90.91%). This is considered positive in relation to the results of the previous studies; the majority of them had a significant effect size. In general, most studies that have addressed the effectiveness of constructive learning approach and developing thinking skills indicates that they have a significant effect size, with a total percentage of (80%), and a total of (76) studies out of (95) studies.

Table (3) shows the effect size of the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and the studies that addressed the effectiveness of constructive learning approach in developing thinking skills that were conducted in the period (2010-2020), according to the study variables (Educational stage, specialization, study type).

Table (3): The Effect Size Means, Standard Deviation, and Trust Interval of the Previous Studies that Addressed the Effectiveness of the Constructive Learning Approach in Acquiring Science Processes and the Effectiveness of the Constructive Learning Approach in Developing Thinking Skills According to Variables

Domain		Science Processes				Thinking Skills			
				Trust Interval				Trust Interval	
Variable		Effect Size Means	Std. Devi	Min	Max	Effect Size Means	Std. Devi	Min	Max
Educational stage	Elementary	4.406	4.460	0.978	7.834	2.778	4.551	0.150	5.406
	Intermediate	3.076	3.324	1.474	4.678	2.242	2.374	1.322	3.162
	Secondary	3.068	2.268	*	6.677	2.806	3.403	*	5.953
	Undergraduate	3.030	*	*	*	1.140	0.113	0.124	2.156
specialization	General Science	3.787	3.838	2.127	5.446	2.624	3.600	1.303	3.944
	Biology	0.950	0.014	0.823	1.077	1.290	0.720	0.689	1.892
	Chemistry	2.864	2.512	-1.133	6.861	3.950	3.861	-30.738	38.638
	Physics	3.235	2.914	-1.402	7.782	2.430	3.051	0.085	4.775
	Earth and Environmental Sciences	*	*	*	*	2.170	*	*	*
study type	PhD Dissertation	4.180	3.622	-4.817	13.177	2.190	*	*	*
	MA Thesis	2.139	1.858	0.810	3.467	1.927	2.139	0.568	3.286
	Published Research Studies	3.973	3.997	2.103	5.844	2.586	3.462	1.448	3.724
Total		3.436	3.469	2.206	4.666	2.423	3.156	1.536	3.311

*** There is no study on the variable.**

By reviewing table (3) the following can be noted:

The Total Effect Size Means: The effect size means of the studies that addressed the effectiveness of constructive learning approach in acquiring science processes reached (3.436), and based on Cohen scale it indicates high level. This can be explained by the fact that most addressed previous studies indicated a high level. This result is consistent with the results of the studies of Cakir (2017), and Aktamis and his colleagues (2016). Furthermore, the total effect size means of the studies that addressed the effectiveness of the constructive learning approach in

developing thinking skills was (2.423), based on Cohen scale it indicates high level. It can be explained by the fact that constructive learning strategies have an effect on developing science processes and thinking skills of the learner, as they make the learner the center of the learning process, and emphasize his active, innovative and social role. Also, it builds his knowledge by himself in structural mental schemes connect the new knowledge with the previous one, through assimilation and adaptation, then organizing and adopting the information. Furthermore, they call for the need for the learner to interact with real experience, which helps him develop his mental capabilities and increase his thinking capabilities in solving problems and making the appropriate decision.

Educational Stage: Elementary school ranked first with respect to the studies that addressed the effectiveness of constructive learning approach in acquiring science processes with an effect size means (4.406), then the intermediate school with a mean of (3.076), and the secondary school with a mean of (3.068), respectively, and finally undergraduate stage with a mean of (3.030).

For the studies that addressed the effectiveness of constructive learning approach in developing thinking skills, secondary school ranked first with effect size means (2.806), followed by elementary school with a mean of (2.778), then the intermediate school (2.242), and finally, undergraduate stage (1.140). This result can be attributed to the fact that the number of studies addressed the elementary and intermediate schools was large; and the researcher's ability to apply his study on these stages is due to the flexibility of applying to the curricula of these stages, and the cooperation of the schools administration with the researcher. Furthermore, the number of elementary school students was big due to the mandatory education by the state; this enhances the researcher's opportunities to choose and implement in more than one school. As for obtaining the first rank by the secondary school in the studies that addressed thinking skills, it can be explained to the researchers' interest in applying the studies addressing thinking skills among secondary schools students, and this requires an effort and to practice thinking by the students, in addition to the interest of some education systems in developing some of the thinking skills among secondary school students, who will soon become university students, as in the Saudi education system, that approved the critical thinking course for the secondary school.

Low effect size means for undergraduate stage can be attributed to the reluctance of researchers from applying their research on this stage, as university students may not have any interest in committing to the research applying procedures, and due to the privacy of the courses of this stage. This result is consistent with the results presented by Yaman and Karasah (2018) results which showed that elementary school had the highest effect size means, while undergraduate stage had the lowest effect size means. It is also consistent with the result of Balta and Sarac (2016) study that secondary school had the highest effect size means, the results differs from the results obtained by Ayaz and Sekerci (2016) concerning the effect size means of the undergraduate stage. Accordingly, it was found that based Cohen's classification all education stages indicated a high level.**Study Type**: PhD dissertation ranked first in the studies that addressed the effectiveness of constructive learning approach in acquiring science processes with an effect size means (4.180), followed by published research with an effect size means (3.973), while published research ranked first in the studies that addressed the effectiveness of constructive learning approach in developing thinking skills with an effect size means (2.586), followed by PhD dissertation with an effect size means (2.190), while MA thesis ranked last.This result can be attributed to the fact that the values of effect size means of PhD dissertation were significant, while the number was small. This result is consistent with the results presented by Balmen and his colleague (2018), Yaman and Karasah (2018), and Sarac (2018) that the PhD dissertation obtained the highest values of effect size, while it differs from the results obtained by Balta and Serac (2016), and Ayaz and Sekerci (2015) in the effect size of MA thesis. As for the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills (together), the effect size means was calculated according to (educational stage, specialization, study type), by calculating the effect size means based on the values of the effect size of the studies, as shown in table (4).

Table (4): Effect Size Means, Standard Deviation, and Trust Interval of the Previous Studies that Addressed the Effectiveness of the Constructive Learning Approach in Acquiring Science Processes and Developing Thinking Skills together According to the Study Variables

	Domain								
Variable		Science Processes				Thinking Skills			
				Trust Interval				Trust Interval	
		Effect Size Means	Std. Dev.	Min	Max	Effect Size Means	Std. Dev.	Min	Max
Educational Stage	Elementary	6.335	4.335	-32.610	45.280	4.220	3.790	-29.833	38.273
	Intermediate	2.785	2.210	0.937	4.632	1.986	1.272	1.008	2.964
	Secondary	1.110	**	**	**	2.160	**	**	**
	Undergraduate	***	***	***	***	***	***	***	***
Specialization	General Science	3.818	2.823	1.648	5.987	2.566	1.890	1.214	3.919
	Biology	1.110	**	**	**	2.160	**	**	**
	Chemistry	0.587	**	**	**	0.654	**	**	**
	Physics	***	***	***	***	***	***	***	***
	Earth and Environmental Sciences	***	***	***	***	***	***	***	***
Study Type	PhD Dissertation	2.330	**	**	**	0.892*	0.342	-2.177	3.960
	MA Thesis	2.225	0.735	1.056	3.394	2.305	1.417	0.050	4.560
	Published Research Studies	4.138	3.658	0.299	7.977	2.912	2.156	0.650	5.175
Total		3.278	2.798	1.398	5.158	2.373	1.797	1.231	3.515

*** There are two values for the effect size in one study using two thinking tests.**

**** The value of standard deviation was not calculated, as there is no other study to find the result of comparison between studies for the same variable.**

***** There is no study on the variable.**

By reviewing the previous table the following can be noted:

Educational Stage: Elementary school ranked first in terms of the studies that addressed the effectiveness of the constructive approach in acquiring science processes and developing thinking skills as the effect size means was reached (6.335) and (4.220) respectively. The intermediate school ranked second with an effect size means

(2.785) and (1.986) respectively. This result can be attributed to the fact that this stage requires to develop the skills of science processes and thinking skills among students. The effect size means for the secondary school in the test of thinking skills was (2.160), and in the test of science processes (1.110), based on Cohen classification it indicates high level. This result can be attributed to the assertion of some education systems for the need to develop thinking skills among students in this stage. The results are consistent with other studies such as Balmen and his colleague (2018), Yaman and Karasah (2018), Sarac (2018), Balta and Sarac (2016), and Ayaz and Sekerci (2015).

Specialization: General science ranked first in term of the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills together, as the effect size means was (3.818) and (2.566) respectively. This can be attributed to the fact that the curricula of general science is intended for the elementary and intermediate schools, where the content of these curricula were developed according to the nature of the constructive theory and the learning cycles, where the student is active, creative, and cooperative with his colleagues in the scientific experiments. Additionally, researchers can easily choose the appropriate units for the nature of their studies and the available time. This result is consistent with Ayaz and Sekerci (2015) findings.

Biology ranked second, with an effect size means (1.110) and (2.160) respectively; based on Cohen classification it indicates high level. This result is consistent with the result of several studies (e.g. Balmen et al., 2018; Yaman & Karasah, 2018; Sarac, 2018; Balta & Sarac, 2016; Ayaz & Sekerci, 2015). While chemistry ranked third, with an effect size means (0.587) and (0.654) respectively, all of which fall into the moderate level in Cohen classification. This result differs from the results found by the previous studies that examined the effect size means of chemistry, as it was significant. As for physics, and earth and environmental sciences, the researcher did not find any study that addressed these curricula.

Study type: published research got the first rank in term of the studies that addressed the effectiveness of the constructive learning approach in acquiring science processes and developing thinking skills, as the effect size means was (4.138) and (2.912) respectively, while MA thesis got an effect size means (2.225) and 2.305) respectively, as for PhD dissertation it got (2.330) and (0.892) respectively. This result can be attributed to the researchers' interest to conduct and publish research studies comes to a greater degree than MA theses and PhD dissertations, also, the number of published research studies is greater than MA theses and PhD dissertations, which are mostly unpublished. This result is differs from the results of other researchers (e.g. Balmen et al., 2018; Yaman & Karasah, 2018; Sarac, 2018; Balta & Sarac, 2016; Ayaz & Sekerci, 2015). Accordingly, it was found that the studies that addressed the effectiveness of the constructive learning approach in acquiring science processes and developing thinking skills indicated a high level.

Third Question: "What is the effect size means for the of the experimental studies conducted in the period (2010-2020), addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills, according to (Sample size, country, and the year of the study)?"

To answer this question, effect size means was calculated for the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills according to the sample size. The previous studies were classified in the meta-analysis in three category based on the sample size: Small ($n \leq 50$); medium ($51 < n \leq 100$); large ($n > 100$) (Balmen et al., 2018; Yaman & Karasah, 2018). The value of the mean for the sample size was ($n = 74$). Table (5) shows the effect size means and the standard deviation of the sample size.

Table (5): Effect Size Means, Standard Deviation, and Trust Interval of the Studies that Addressed the Effectiveness of the Constructive Learning Approach in Acquiring Science Processes and Developing Thinking Skills According to the Sample Size

Domain	Number	Std. Devi.	Trust Interval

	Sample Size		Effect Size Means		Min	Max
Studies Addressed the Constructive Learning Approach in Acquiring Science Processes	**Small**	**4**	**3.230**	**3.819**	**-2.847**	**9.306**
	Medium	**23**	**3.568**	**3.290**	**2.145**	**4.991**
	Large	**6**	**3.068**	**4.512**	**-1.667**	**7.802**
Studies Addressed the Constructive Learning Approach in Developing Thinking Skills	**Small**	**8**	**1.491**	**0.730**	**0.880**	**2.101**
	Medium	**33**	**3.117**	**3.727**	**1.796**	**4.439**
	Large	**10**	**0.879**	**0.588**	**0.459**	**1.300**
Studies Examining the Two Variables - Science Processes**	**Small**	**1**	**1.900**			
	Medium	**10**	**3.416**	**2.910**	**1.334**	**5.497**
	Large	***	***	***	***	***
Studies Examining the Two Variables - Thinking Skills**	**Small**	**1**	**2.100**			
	Medium	**11***	**2.398**	**1.883**	**1.133**	**3.663**
	Large	***	***	***	***	***

*** The previous studies that addressed the constructive learning approach on acquiring science processes and developing thinking skills (together).**

**** There are two values for the effect size in one study using two thinking tests**

***** There is no study on the variable.**

Table (5) shows that the effect size means for the sample size (medium) got the higher value and ranked first in all the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills, as it was (3.568), (3.117), (3.416), (2.398) respectively. Sample size (small) ranked second in all the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills, with an effect size means (3.230), 1.491), (1.900), (2.100) respectively. While sample size (large) ranked last, with an effect size means (3.068), (0.879). The results can be attributed to the researchers' interest in applying their studies on a medium size samples, depending on the number of students in the classes, additionally, the researcher will get a better result for the instrument of the study by increasing the sample size. The results differs from the results of those by Balmen and his colleagues (2018); Yaman and Karasah (2018); Sarac, 2018; Balta and Sarac, (2016); and Ayaz and Sekerci (2015).

To show the effect size means of the experimental studies addressed according to country, the effect size means was calculated for the studies that addressed the effectiveness of constructive learning approach in acquiring science processes and developing thinking skills, as shown in table (6).

Table (6): Effect Size Means and Standard Deviation of the Studies that Addressed the Effectiveness of the Constructive Learning Approach in Acquiring Science Processes and Developing Thinking Skills According to Country

Domain

	Science Processes			Thinking Skills			Studies Examining the Two Variables - Science Processes**			Studies Examining the Two Variables - Thinking Skills**		
Country	**Number**	**Effect Size Means**	**Std. Dev.**	**Number**	**Effect Size Means**	**Std. Dev.**	**Number**	**Effect Size Means**	**Std. Dev.**	**Number**	**Effect Size Means**	**Std. Dev.**
Jordan	**10**	**2.839**	**4.506**	**11**	**2.104**	**1.653**	**2**	**1.459**	**1.232**	**2**	**0.652**	**0.003**
UAE	**1**	**4.850**	*									
Saudi Arabia	**10**	**3.945**	**3.595**	**15**	**1.783**	**2.407**	**1**	**1.110**	*	**1**	**2.160**	*
Oman	**3**	**2.867**	**2.458**				**1**	**2.900**	*	**1**	**1.680**	*
Iraq	**2**	**1.245**	**0.021**	**6**	**0.967**	**0.618**						
Palestine	**5**	**3.812**	**2.477**	**7**	**2.315**	**2.745**	**4**	**2.225**	**0.735**	**4**	**2.305**	**1.417**
Kuwait				**4**	**1.602**	**1.246**						
Egypt	**2**	**5.273**	**4.818**	**7**	**6.421**	**5.755**	**3**	**6.743**	**3.409**	**3**	**4.327**	**2.241**
Yemen				**1**	**0.338**							
Total	**33**	**3.436**	**3.469**	**51**	**2.423**	**3.156**	**11**	**3.278**	**2.798**	**11**	**2.486**	**1.840**

*** The value of standard deviation was not calculated, as there is no other study to find the result of comparison between studies for the same variable.**

By reviewing table (6), it found that the value of the effect size means in all the addressed studies was higher in Egypt, as it ranked first in all the studies. UAE followed it in the value of the effect size means in the first domain (Science processes) with a value of (4.850), while Saudi Arabia got the highest value of the effect size in the first domain (Science processes) with a value of (3.945).

Based to Cohen classification, it was found that most of the previous studies indicates a high level, except a study in Jordan (Studies examining the two variables - thinking skills) that registered a moderate level with an effect size means (0.652), and a study in Yemen (Thinking skills) that registered a simple level with an effect size means (0.338). This can be attributed to the nature of the educational curricula in the country, and researchers' trend towards investigating the effectiveness of the constructive learning approach. Additionally, this result can be attributed to the fact that the education systems in the some countries emphasizes the use of strategies based on constructivism theory as a result of designing the content of its courses according to the basics of constructivism theory. Within the limits of access to previous studies, there was no study examining the size effect means of the

Arab countries in constructivism research, while USA obtained an effect size means (0.88) as in the study of Firman, Ertikanto and Abdurrahman (2019).

In order to define the type and number of the previous studies addressed in the Arab countries and how they were distributed based on the years of the study (2010-2020); the studies types were classified according to the country and the year of the study, as shown in table (7).

Table (7): Type and Number of the Studies that Addressed the Effectiveness of the Constructive Learning Approach in Acquiring Science Processes and Developing Thinking Skills According to the Country and the Year

Country	Jordan			Saudi Arabia		Kuwait			Oman		Iraq	UAE	Yemen	Palestine		Egypt	Total
Year	PR*	M**	P***	PR*	M**	PR*	M**	P***	PR*	M**	PR*	P***	PR*	PR*	M**	PR*	
2010	2			1			1	1		1	1	1		2			10
2011	2													1			3
2012	1			5	1				1					1	1	1	11
2013	1			1	2					1				1		1	7
2014	1	1			1						1			1		2	7
2015		1	2	3											2		8
2016	1			2					1		2		1		2	3	12
2017	2	2		2	1						2			2	1	1	13
2018	2	1		5		1					1					2	12
2019	1	2	1	2		1					1			1	1	2	12
2020																	
Sum	13	7	3	7	5	2	1	1	2	2	8	1	1	7	9	12	95
Total	23			26		4			4		8	1	1	16		12	

*** Published Research Study**
**** Master Thesis**
***** PhD Dissertation**

Table (7) shows the following:

- According to the study type, published research studies ranked first, which was largely conducted in (2010-2020) in Egypt, Yemen and Iraq, followed by MA theses that were conducted in different countries and years. Finally, PhD dissertations conducted in Jordan (3); Kuwait (1), and UAE (1). This can be attributed to the researchers' interest in conducting experimental research studies and publishing them, where their large numbers helped increasing the number of published research studies, while MA theses and PhD dissertations may not be published quickly, and the number of students in these two stages is less than the number of researchers.
- According to the year of the study, 2017 yielded the largest number of previous research studies (13 studies), followed by 2016, 2018, 2019 with (12) studies for each of them, 2012 ranked third with (11) studies, then 2010 with (10) studies, and finally, 2011 with (3) studies. While the researcher did not find any study in 2020. The values of the effect size means for (2010-2020) ranged (0.997-7.93), based on Cohen classification it indicates a high level, and this is consistent with the study of Yaman and Karasah (2018).
- According to the country, Saudi Arabia ranked first with a total of (26) studies, followed by Jordan with a total of (23) studies, Palestine (16) studies, Egypt (14) studies, and Iraq (8) studies respectively. Oman

and Kuwait got the same ranking with (4) studies for each, and finally UAE and Yemen with only one study for each. The largest number of published research studies were in 2012 and 2018, as Saudi Arabia conducted (5) studies, then Egypt with (3) studies in 2016. With regard to UAE, it conducted one PhD dissertation in 2010, and Yemen conducted one published research study in 2016. As for MA theses, they were distributed between countries and in different years. This can be attributed to the fact that educational systems are interested in investigating the effectiveness of constructive learning approach in science curricula, especially since Saudi Arabia has adopted designing the content of science curricula based on the constructivism theory.

Conclusion

The final results can be summarized as follows:

- Constructive learning has a positive effect on acquiring science processes and developing the different thinking skills in science, in the different educational stages with a moderate sample size.
- The effect size means in term of the studies that addressed constructive learning approach in acquiring science processes was (3.436); for the studies that addressed the effectiveness of constructive learning approach in developing thinking skills it was (2.423); while for the studies examining the two variables it was (3.278) and (2.373) respectively, based on Cohen classification it indicates high level.
- The published research studies had the highest percentage in the study sample comparing to MA thesis and PhD dissertations, with a percentage of (67.37%).
- The researched previous studies in general science were (66.32%), it explains the large number of studies in the elementary and intermediate schools.
- The researched previous studies selected the random sample with a higher percentage than the purposeful sample with a percentage of (51.58%).
- Most of the researched previous studies used medium sample size ($51 < n \leq 100$); as the sample size means was (74).
- Most of the researched previous studies used T-Test for Independent Samples, with a percentage of (64.21%).
- The effect size means of all the researched previous studies (Published research studies, MA thesis, PhD dissertation) was significant, based on Cohen classification it indicates high level.
- Saudi Arabia ranked first in the number of the researched previous studies with a total number of (26) studies, followed by Jordan with a total number of (23) studies, and the peak of the researched previous studies was in 2017.

Recommendations

In light of the results, the study suggests:

- Conducting future research studies define the effectiveness of constructive learning approach at the secondary school and undergraduate stage.
- Encouraging PhD students and researchers to address constructive learning in the research of physics, chemistry, and biology, specifically earth and environmental Sciences.
- Conducting studies on a large sample size, for further investigation of the effectiveness of constructivist learning approach.
- Preparing a research map that includes the distribution of research over the coming years, including curricula and educational stages.
- Conducting experimental research studies address both science processes and thinking skills in the constructive learning approach in the various educational stages and specialization.

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