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The Impact of Using V-Shape Maps in Teaching Physics Laboratories on Undergraduate Students' Academic Attainment

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Abstract

The current study uses a method termed "V-Shape maps" to investigate the influence of educating undergraduate students' physics laboratories on their academic achievement. Some methods were used on a sample of 40 students from various colleges of science at Applied Science Private University in Amman to answer the study's questions and evaluate its hypotheses. Pupils were randomly selected and placed into two groups, each with twenty students. The first group, known as (the experimental group), was taught using the V-shape mapping technique, whereas the second group, known as (the controlled group), was taught using the usual method. The following two tools were utilized in the research:

1.Subjecting students to exam to measure their attainments in the practical physics once before and once after using each strategy.

2.Measuring the attitudes towards physics before and after applying each strategy.

The stability and honesty of these tools were assured. The study shows a statistical difference at the rate of 0.05 between scores' average and standard deviation of the students who have studied the practical physics by the map's strategy of the V-shape maps (the experimental group) and the scores' average of the students who have studied by traditional ways. The study also displays statistical differences at a significant level of 0.05 on the students' average of the attitudes' measurement toward physics concerning the teaching-learning process and the differences were in favor of experimental groups.

Keywords: V-shape maps, Physics Laboratories, Learning, Hypothesis

Introduction

The stage of the tremendous development and technological progress in science is called "Scientific Revolution" which caused an increasing in both of the quantitative and qualitative data and knowledge in many aspects of our lives. Therefore, the recent studies, particularly in the scientific fields, have tend to look for new methods and strategies of teaching because the meaningful learning is the desired gain (Yusra, 1993).

Probably the lecture method in teaching is the most ancient one, still widely spread in most countries of the world, in which the teacher facilities information sequentially to the students in the lectures, such information talks about events, facts, data or experiences without motivating students to participate. Generally, this method is called the traditional method of teaching, and it is based on an old educational theory according to which the student's mind is a blank page on which information is engraved or an empty container the teacher fills with

knowledge (Salamah, 2002). Teachers emphasize that education generally and science teaching in particularly, is not merely a process to transfer the scientific knowledge to the students, but rather a process concerned with the students' mental, emotional and skill development, and the integration of their personalities in all its aspects. The major task in science teaching is to teach students how to think, not how to memorize information of courses and books (curricula) without understanding, realizing or applying them in life. (Zaytoon, 1994). Teaching is the vital interaction between students, teachers and various elements of the environment that the teacher warms up for the students in order to provide them with information, skills, behaviors and trends that should be achieved in a specific period of time known as the lesson. In this process, teacher uses lots of methods that should be prepared well and students have to be warmed up regardless of his fluency of the language, care and the starting point for developing teaching methods. Therefore, teaching becomes a broader concept that expresses the process of using the learner's environment and making an intentional change in it by reorganizing its elements and components to achieve intended and limited goals (Salama, 2002). Taking a look at science as a system of concepts, the framework proposed by Ausuble is appropriate for teaching, where Ausuble sees that the educational material or content consists of a set of concepts that can be converted into ideas and information that are stored in memory or can be retrieved and used in teaching and understanding information. The most substantial point that Ausubel focuses on in his theory is meaningful learning for the learner (Salama, 2002). Zaitoun (1994) indicated that the results of educational studies and research in science teaching signalize that there are some difficulties in learning and acquiring scientific concepts due to the contradictions in the scientific concepts themselves. In terms of its types, simple or complex, material or abstract, science teachers have found themselves compelled to propose new methods for teaching concepts that keep pace with zeitgeist.

Meaningful learning:

Osbel's theory of what he called "meaningful learning" was assumed during his work between 1963 and 1969. In this theory of learning, he supposed that the concept or mental development of an experience acquires a true psychological meaning when it is equivalent to a pre-existing idea. Hence, teachers must present the educational material in an orderly and consecutive manner (Qatami and Qatami, 1998). Ozbel identified three main steps for organizing knowledge in the individual's mental structure, as indicated by them (Al-Khalili and his companions, 1996), which are:

1- *Hierarchical organization of the knowledge structure (Hierayachaially Organized)*: This means that the information in the mind of the learner should be arranged from the most general and comprehensive to the least general and comprehensive. The least means the least comprehensive. It follows that new information is often able to be linked and included in concepts higher than it.

2- *Progressive Differentiation*: Here (Ozbel) sees that concepts are never learned definitively, but rather are learned successively so that they become more comprehensive after each successive discrimination. Concepts that were less comprehensive acquire greater meanings the more the individual learns new concepts that fall under them, that is, the sequential, organized principles and concepts that make up the individual's cognitive structure are constantly subject to modification. Concepts that are less comprehensive for the individual, in a particular educational situation, become more comprehensive, in a subsequent

educational situation, and occupy higher positions in the cognitive hierarchy, that is, less general concepts fall under them.

3- *Integrative Reconciliation*: Meaningful learning becomes better when the learner realizes new correlations between interrelated sets of concepts and assumptions. When the individual feels that there is a correlation of similarity or contradiction between an interrelated set of concepts and assumptions and another interconnected set of concepts and assumptions, the so-called integrative reconciliation occurs, which improves learning.

4- *V-shape Maps*: Gowin has invented a method that encourages self-learning, such method is very useful in helping people understand the formation and structure of knowledge and how it is created. Figure (1) represents a simplified image of the V-shape map of the joint. At the top of the V-shape map there are events or things, at this point where the formation of knowledge starts from some sides. If we want to observe regularity, it may be necessary to select certain events or things from our environment, to observe them carefully and make some kind of recording of our observations, this process of selection and recording requires concepts that we have already known, such concepts will influence the quality of events and things we choose to observe and the quality of recording we do. These three elements – concepts, events and things, recording events/things (which we call facts) are mixed up and overlapped when we try to form new knowledge. When students become confused about new concepts they are trying to learn, the problem is usually here at the vertex of the V-shape map where students need help recognizing:

1) What events or things do they notice?
2) What concepts do they know relating to these events or things?
3) The recordings they deserve. (Novak and Gowin, 1991).

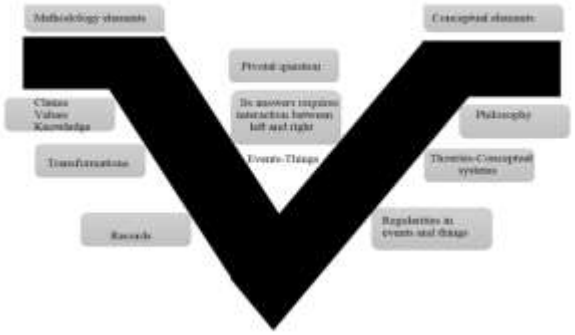

Figure 1: V-shape map

Figure 1 displays theoretical or conceptual elements of methods and means that interact with each other in the process of building knowledge or analyzing lectures or documents that represent knowledge. The V-shape map is a schematic figure that shows the correlation between events, objects, conceptual and procedural elements that lead to understanding knowledge. It can be considered as an educational tool that reveals the correlation between its elements and its use leads to the fulfillment of meaningful learning as it gathers information contained in the cognitive structure for students and new information, which achieves harmony in the cognitive structure as a whole (Al-Tantawi, 2000). This shape shows the relationship between the elements of the conceptual side and the procedural side in an integrated way that reflects the nature and characteristics of science (Shehab and Al-Jundi, 1999). Moreover, it enables us to help students to realize that the learning fixed point lies in each of the events and objects being observed and the validity of the recordings we choose to make and

in the quality or adequacy of the ideas that adjust and direct the research process. No one has absolute authority to make epistemological claims because no one has the accurate concepts and the best ways to make the recordings, consequently the students do not understand well. In this case, it seems that nothing worth learning, the form of knowledge (vee) helps them realize that they can take an active role in judging the truthfulness of claims and that learning becomes meaningful when they are able to be responsible for it (Novak and Gowin, 1991).

The V-shape map is used for several purposes: it is used as an educational tool, an evaluation tool, a methodological tool, in critical reading of the proposed research in various fields and as a tool for analyzing learners' responses during personal interviews (Salama, 2002).

Problem Statement, Research Hypothesis

Predominantly, when students enter the laboratory, wondering what they are supposed to do or see, their confusion is so great that they do not know the regularities to observe between events and things and what important correlations between concepts.

as a consequence, they write reports, handle devices or construct formations without much purpose and without enriching their understanding of the correlations they observe or deal with (Novak and Gowin, 1991). The researcher noticed, through his experience in the field of education and teachers shared him that the clear decline in students' attainments generally and in physics particularly. In addition to the lack of creativity in this field which sparked interest in searching for other methods that contribute in increasing the level of attainment of learners, it was noted that students were weak in acquiring, retaining concepts, retrieval and transmission of the impact of their learning, perhaps all of these are due to the traditional method of teaching in our educational institutions, which requires the student to solve problems and conduct scientific experiments in a fruitless way rather than being meaningful. The undergraduate students were chosen to apply this study since the strategy of V-shape maps requires students to learn the nature of knowledge and understand how they learn. Accordingly, this study aimed to investigate the effect of using a teaching strategy using V-shape maps on student attainments. Specifically, it aimed to answer the following question:

- What is the effect of using the V-shape map strategy on the academic attainment in practical physics-1 of undergraduate students of the university?

In light of the previous question, the hypotheses of the study were formulated as follows:

- There is no statistically significant difference at the level of significance ($\alpha = 0.05$) between the arithmetic mean of the scores of undergraduate students who learned practical physics-1 using the V-shape map strategy (the experimental group) and the average attainment of their colleagues who learned it by the traditional method (control group).

Procedural definitions of the study

a- *The V-shape map*: An educational tool that shows the interaction between the conceptual side of a branch of knowledge and its procedural side where events and things are located in the center of the V-shape in which knowledge construction begins, this tool also reflects the nature of science and its characteristics.

b- *Practical Physics-1*: The practical course related to the mechanics contained in the laboratory's manual for practical physics-1 in the second semester at Applied Science Private University in Jordan.

c- *Attainment tests*: tests that are designed to reveal the knowledge that learners acquired to aid in satisfying the objectives of the course. In this study, it is measured procedurally by the learner's

scores obtained in the attainment test in the practical physics-1 among the students in the first academic year.

d- *Traditional method*: a method of teaching the course material without using the V-shape map strategy. This method is based on the previously prepared laboratory manual, where the teacher begins by presenting the objectives of the experiment and then explain and derive the laws in an ordinary way, give cognitive principles and clarifying how devices and tools work in the laboratory in front of the students to do the work, then fill out the assigned tables, draw the data graphically and finally extract the results.

Study Restrictions

• Limited to two sections at Applied Science Private University in the second semester.
The experiments were limited to four topics in practical physics-1 related to mechanics.
• The experiments were restricted to the V-shape maps, which were built for this purpose and the generalization of its results was limited to the boundaries of these maps.
• Limiting the experiments to the research tools used to measure attainment where such tools have characteristics that differ from other tools that measure the same characteristics.

Method and Procedures

Participants:

The participants are students of the Applied Science Private University in Amman, who take practical physics-1 and their total number is 80 students divided into four divisions, twenty students for each class and who take this subject as a compulsory requirement in their different specializations. The possibilities to implement the study are available from advanced laboratories and modern equipment and devices. The two sections were randomly chosen and one of them was assigned to be an experimental group and the other a control group in a random manner. Number of students in the experimental group was 20 and the control group 20 as well. The experimental group was taught using the V-shape map strategy, while the control group studied the same educational material using the traditional method.

Study Tools

1- **Attainment test:**

This test was prepared specifically for the purposes of this study in order to measure students' attainment in practical physics-1. In its final form, the test consisted of 24 objective paragraphs, each one contains four alternatives. The test was prepared according to the following steps:

a. We analyzed the topics to be taught (4 topics in practical physics-1), extracted the basic scientific concepts and generalizations contained therein.
b. The test was prepared in its initial form: Bloom's classification of question levels was adopted and a specification table was made to verify the content validity of the test. The questions were provided with illustrations that help the student understand the question, and to reduce the impact of the students' reading level on their performance on the test.
c. The test was presented in its initial form to reviewers in the fields of physics, education, psychology and science teaching, including university professors, laboratory supervisors, educational supervisors and physics teachers, using the questionnaire in Appendix (4) to review the test items and judge them according to the following criteria:
*Paragraph level fits Bloom's classification of goal levels.

* the correlation between the paragraph and the content of knowledge of the subject intended is taught.
* Clarity of the grammatical formulation of the paragraph and thus clarity in defining the cognitive domain of the student's response.
*Matching the paragraph level with the student's ability level at the university level.
* Appropriate alternatives to the paragraph.
* Expressing opinions and observations concerning the paragraph or the proposed amendment to the paragraph or alternatives and canceling some inappropriate paragraphs, so that it becomes in its amended final form.
*After taking the opinion of the reviewers, the test consists of 24 multiple-choice items. The stability of the test was calculated by Cörnbach's equation (α) for the individuals of this study and it was found that the reliability coefficient was equal to (0.95) and the difficulty and discrimination coefficient was calculated for each paragraph. The coefficient of difficulty ranged between (0.20 - 0.80) and the coefficient of discrimination (0.60 - 0.80).

Educational material (lesson preparation's notes)

An educational material has been prepared for four consecutive topics of practical physics-1, such topics are related to mechanics, based on the laboratory manual for undergraduate students. Several steps were taken in preparing the educational material according to the strategy of V-shape maps, as follows:

a- The selected topics were analyzed in the laboratory manual and each topic was allocated a special lesson. The number of topics was (4) and each topic was allocated (3) consecutive hours, including two parts: a theoretical part that is given at the beginning and a practical part after the completion of the theoretical part, where one topic is given once every week. The total number of total hours given was (12) over (4) weeks at a rate of (3) hours per week.

b- Notes were prepared to display the laboratory teaching plan based on the V-shape maps strategy, 4 notes were included in a specific topic talking about a specific idea and each note was given in one laboratory class at a rate of (3) hours per week. The four notes were generally characterized when they were prepared; they are: starting from the strategy of V-shape maps, highlighting scientific concepts, principles and generalizations, containing them on educational activities and a special memorandum has been designed in the traditional way.

c- The memos that were prepared were presented to reviewers who are specialized in physics and others specialized in methods of teaching science, education and psychology. They were asked to express their opinion of the suitability of memos to the students and the extent to which they represented the strategy of V-shape maps and were amended in the light of their observations.

Study Procedures

The study was carried out according to the following steps:

1. Procedures for preparing the educational material:

- Analyze the content of the educational material represented in the subject

(mechanics) from the laboratory manual and the practical physics-1 textbook in the second semester.

- The V-shape maps were prepared for the four selected topics of practical physics-1 related to mechanics to be relied upon in the teaching process. These maps were designed based on references related to this subject beside the laboratory manual and the university physics book.

The four topics are:

• Average velocity and instantaneous velocity.

• Projectile motion

Newton's 2nd law

Friction

- The educational material was prepared in the form of notes using the V-shape maps, which were used in this study, in addition to the V-shape maps that were designed on the four previously mentioned topics.

2. Preparation of study tools: an attainment test was prepared to measure students' understanding of the information contained in the given material, a research that included most of the cognitive aspects, a measure of students' attitudes towards physics and to verify the validity and reliability of each of them according to what was mentioned in the study tools item.

3- Procedures for selecting individuals: The experimental group and the control group were randomly chosen from the undergraduate students of the university.

4- Procedures for applying and following up the experiment:

- The approval of carrying up the study was taken by the concerned authorities at the university where the researcher works as a physics laboratory supervisor where he conducted the teaching process for the control and experimental groups in order to ensure that the study was applied correctly and so that there was no impact resulting from changing the teacher.

- The researcher gave two practical sessions to another sample using the V-shape maps in front of reviewers to verify the researcher's ability to master the use of the method as described and the observations made on it were taken into account.

-The time dedicated to the laboratory was appointed so that the physics laboratories for the experimental and control group would be on two consecutive days at the same time, in order to facilitate the transition, give laboratories in a smooth way and to cancel the effect of the laboratory appointment.

-The direct attainment test and the measure of attitudes towards physics were applied to the experimental and control groups before starting the experimental treatment, taking into account that the time was sufficient for the tests.

- The study was implemented on second semester with a practical lecture per week for three hours, where the hours given to each group amounted to (12) actual hours. After completing the teaching process for the two groups, the attainment test was given by the researcher and laboratory supervisors from the university.

Analysis of the results

The pre and post tests were manually corrected according to the key answers

form for each of them and the scores of each student were recorded along with his name in a special record and were processed using the computer. An analysis of variance (ANCOVA) was used to compare the results of the two groups.

Study design and statistical treatment

This study is quasi-experimental, where the experimental and control group were randomly chosen, but according to sessions. Where the students were not randomly distributed between the experimental and control groups.

The current study is based on investigating the effect of using the V-shape map strategy on the attainment of the undergraduate students in the physics laboratories, so the independent variable is the teaching strategy and it has two levels:

Teaching strategy using V-shape maps.

*Traditional teaching strategy.

The group that studied using the V-shape maps strategy was considered the experimental group, while the group that was taught by the traditional method was considered the control group.

The dependent variable is:

- the collection

Figure (2) below shows the design of the study:

	Students' Attainment in Practical Physics		
Experimental	O1	X	O2
Controlled	O1	X	O2

X: Processing

Figure 2: Study Design

Statistical treatment

An analysis of variance (ANCOVA) was used to find out the effect of the teaching method on the dependent variable: the students' attainment in the course, after taking in consideration his/her performance in the pre-test as a covariate.

Results

The current study aims to investigate the effect of using the strategy of teaching V-shape maps on the attainments of the undergraduate students in the physics laboratories and in light of the previous questions, the hypothesis of the study was formulated as follows:

- There is no statistically significant difference at the level of significance ($\alpha = 0.05$) between the arithmetic mean of the scores of students who learned practical physics-1 using the V-shape map strategy (the experimental group) and the average attainment of their counterparts who learned it in the traditional way (control group).

After the completion of the experiment, the final tests were applied to the two groups. The results of the study are described below.

Results Related to Study Hypothesis

To answer the question proposed in first hypothesis, the arithmetic mean and standard deviation of the students' scores achieved on the pre and post-attainment test for the experimental and control groups were calculated and the modified dimensional mean was calculated after taking the covariance variable into account; It is the performance on the pre-test. Table (1) shows that the arithmetic mean of the scores of the experimental group on the pre-attainment test was (12.85) with a standard deviation of (3.65) while the arithmetic mean of the scores of the control group on the same test was (13.15) with a standard deviation of (3.72) and an apparent difference of (0.30). Between the two averages, it was in favor of the control group.

Table (1) also shows that the average arithmetic mean of the scores of the students who studied using the V-shape maps strategy reached

(16.98) while the arithmetic mean of the scores of the students who studied in the traditional method was (13.47) with an apparent difference of (3.51) in favor of the experimental group. In order to find out whether the difference is statistically significant between the two teaching strategies on achievement, an analysis of covariance (ANCOVA) was used, and Table (2) shows the results of this analysis.

The results shown in Table (2) indicate that there is a statistically significant difference at the level (α = (0.05)) in the attainment due to the teaching strategy (V-shape maps vs the traditional method) and in favor of the strategy of the V-shape maps. calculated statistic F is (92.316) and at a level of significance (0.000), as the modified mean for the experimental group was (16.98), while the average for the control group was (13.47). Accordingly, the first null hypothesis was rejected.

Table (1): Arithmetic means, standard deviations, and arithmetic averages modified for students' scores achieved on the pre- and post-attainment tests of the experimental and control groups for the achievement test

Student's Group	Number of Students	Pre-test		Post-test		Modified arithmetic Mean
		Arithmetic Mean	Standard Deviation	Arithmetic Mean	Standard Deviation	
Experimental	20	12.85	3.65	17.60	3.21	16.98
Controlled	20	13.15	3.72	14.15	3.12	13.47
Total	40	13.00	3.68	15.87	3.16	15.22

Table (2): The results of the analysis of the one-way covariance of students' scores on the post-test in attainment after taking the variable (performance on the pre-test) into account.

Variance Resource	Sum of Squares	Degrees of Freedom	Mean Square	F-Statistic	Sig.
Pre-test	326.902	1	326.902	*222.145	0.000
Post-test	135.849	1	135.849	*92.316	0.000
Err.	54.448	37	1.472		
Modified Total	500.375	39			

* Statistically significant.

Discussing findings

This study aimed to investigate the effect of using the V-shape map strategy on the attainment of the undergraduate students in practical physics. The results obtained were presented, and the following is a discussion of those results:

Results related to the study hypothesis

The results of the analysis of the performance of the study sample in the post attainment-test showed that there were statistically significant differences at the level of significance (α = 0.05) in favor of the experimental group in the level of students' attainment in practical physics. In light of the result, it can be said that the V-shape maps strategy outperformed the traditional method in raising and improving the level of attainment of the students in practical physics. This result is consistent with the results of studies (Al-Masry, 2003; Al-Ghanam 1997; Esiobo & Soyibo, 1995; Leman et al, 1985).

This result can be attributed to the following reasons:

• The experimental group learned using the V-shape maps strategy as metacognitive strategies, which focus on acquiring concepts, solving problems and interpreting phenomena (Al-Rawashdah, 1993), compared to the traditional method, which often focuses on memorizing information and facts without focusing on how to build scientific concepts.

• The teaching using V-shape maps strategy contributed to an appropriate process of correcting misunderstandings and it can also be used as meaningful learning aids (Passmore, 1998).

• It may be that the cooperative use of V-shape maps enhances comprehension, due to the multiple points of view that the student is exposed to (Roth & Roychoudhury, 1993).

• It is possible that the students in the experimental group were able to generalize meaning from the data, make connections between procedures, data and requirements, encourage metacognitive awareness, improve conceptual change, improve reflective awareness, as well as increase the level of scientific thinking (Keys et al. 1999).

Recommendations

Based on the results of this study, the researchers recommend the following:

• Conducting further studies that:

- Deals with the effect of using the V-shape maps strategy in teaching physics and other theoretical and practical scientific subjects for different grades and classes.

-Dealing with the effect of using the V- shaped maps strategy on students, their learning style and their personality traits.

It measures the supra-cognitive thinking skills of students at different levels and the factors that work to improve them.

- Examines the impact of using this strategy as an evaluation tool and methodological tool.

• The Ministry of Education adopted the strategy of V-shape maps previously, by holding training courses for teachers of science and other subjects on the use of that strategy and training students to use metacognitive skills.

-Universities and colleges of educational sciences include this strategy in their pre-service teacher education programs, because of the effectiveness of this method in preparing creative teachers.

Curriculum administrators organize school science books in a way that allows the teacher to use the V-shape maps strategy and re-design the educational material in accordance with this strategy, taking into account the level of students' understanding and the link between the practical and conceptual sides.

• Increasing the number of lessons devoted to teaching different scientific subjects so that the teacher can apply new methods of teaching such as V-shape maps.

• Applying this strategy to university students in various subjects in proportion to the nature of the subject after holding courses for professors in universities to familiarize them with different teaching methods and choose the best teachers to work on:

- The need for renewal in the educational strategies currently used to increase their motivation towards learning.

Providing a flexible environment that allows students the freedom to express, respect, exchange their ideas and encourage them to express their opinions without fear.

Diagnosing students' concepts and extracting common errors through the use of metacognitive strategies such as V-shape and conceptual maps and then correcting these conceptual errors.

- The need to listen to students' opinions about the use of new educational strategies such as V-shape maps.

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Declaration of Competing Interest

Authors declare that they have no conflicts of interest to disclose.

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