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The Impact of Modeling and Role Play on Grade Eleven Students' Achievement and Motivation While Teaching Krebs Cycle in Biology

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Abstract

This study investigated the effect of applying "participant modeling" followed by a role play on grade eleven scientific students' achievement and motivation in biology. Students usually face problems in understanding difficult biology concepts like Krebs cycle which is composed of a series of biochemical reactions with many molecules and compounds involved. The researcher designed t-shirts with information about the molecules and the reactions of Krebs cycle and students were asked to wear them throughout the teaching/learning process. Implementing participant modeling helped students to memorize the names of the molecules, their role. Then a role play was applied after modeling to relate the chemical reactions together. Nineteen students with ages ranging between 16 and 17 (N=19) enrolled in grade eleven scientific participated in this study. Data was collected using pre and post-achievement tests, and a motivation test that was implemented before and after the intervention. Results showed a significant enhancement in achievement, but no significant change occurred at the level of motivation. Ultimately, recommendations related to both methodology and future researches are offered.

Introduction

Students usually face problems in understanding difficult biology concepts. Finley, Stewart and Yarroch (1982) reported that cellular respiration, protein synthesis, photosynthesis, Mendel's genetics, mitosis and meiosis, were difficult and important topics for students to learn. There are many reasons behind such problems, possible sources of students' difficulties in learning can be attributed mainly to the high-school biology curriculum, abstract nature of science, teaching learning strategies, textbooks, and insufficient laboratory conditions and equipment (Tekkaya, Ozkan, Sunjur, 2001). There are other reasons behind this problem that are related to motivation at different levels. According to Ogunmade (2005) the lack of motivation for most teachers, poor infrastructural facilities, inadequate textual materials, attitude of students towards learning, lack of teaching skills and competence by science teachers, and lack of opportunities for professional development of science teachers. Based on that, new techniques and teaching methods are needed to explain these topics to provide lifelong learning, and to clarify the vague concepts. Any teaching method adopted by science teachers should encourage interaction among learners and their environment rather than 'spoon feeding' learners with stuffs (Ameyaw, 2015). There is good reason to explore other instructional approaches for teaching science different from the one predominantly used (lecture) for very long time (Ajaja, 2013).

Grade eleven scientific students, in Lebanon, face difficulties in understanding and memorizing the concept of cellular respiration and specifically the concept of Krebs cycle. According to the Lebanese curriculum, the learning objectives for this class requires to relate the biological mechanisms leading to the synthesis of ATP (Oxidation-reduction), infer that the formation of ATP molecules necessitates the intervention of enzymes, and infer that ATP formation is done in the hyaloplasm (fermentation) and in the mitochondria (Krebs cycle/cellular respiration). Krebs cycle is composed of a series of biochemical reactions that represents the final common pathway in all aerobic organisms for the oxidation of amino acids, fats, and carbohydrates, and that converts the citric acid from food into carbon dioxide and ATP. Many molecules and compounds are involved in the cycle; the students should memorize their names and understand their structure in order to determine the sequence of reactions. For this reason, new techniques and teaching methods should be implemented in order to make this concept easier for students. In order to introduce concepts that contain cycles such as glycolysis and Krebs cycle, modeling followed by a role play was suggested to be implemented. This teaching method might help students to be engaged and meet their different learning styles; in addition, this might help them to understand the concept better and to be more motivated.

Models are simplified representations of more complex systems that help scientists structure the knowledge they acquire (Bryce et al., 2016). A model is also a representation that abstracts and simplifies a system by focusing on key features to explain and predict scientific phenomena (Schwarz et al., 2009). Models have become integral teaching and learning tools woven throughout the Next Generation Science Standards (NGSS) since it reflects science in practice (Bryce et al, 2016). In addition, it focuses on the construction and refinement of scientific models and how teaching-learning processes relate to the construction of mental models (Nicolaou & Constantinou, 2014). Moreover, models provide an environment for interactive student engagement. Modeling is a central component of modern science which helps students to learn the nature of science while being engaged. Thus, involving students in scientific modeling is a way to enable learners to appropriate practices as a part of scientific literacy (Schwarz, 2009). Models are very powerful bridges that make unfamiliar phenomena closer to the children's thoughts when used in science education (Gödek, 2004). Models simplify complex systems for students but it's like inquiry, it's not a single method, but rather a complex suite of strategies (Passmore, & Svoboda, 2011).

According to Encyclopedia of Mental Disorders (2017), the factors that increase the effect of modeling are: first the model should be close to reality and to the original copy of the model, second the goal of using a model should be clear for students and highly presented with the model. There are four types of modeling: "live modeling" which refers to watching a real person perform the process the student has chosen to learn, "symbolic modeling" which includes filmed or videotaped models, photographs, picture books, and plays demonstrating the process. "Covert modeling" which students are asked to use their imagination, visualizing a particular behavior as the teacher describes the imaginary situation in detail and "participant modeling" which involves demonstration and practice of the intervention steps in the setting of implementation. The fourth type of modeling, "participant modeling" could be a prior action to role plays, by which students could be modeling the elements required for a specific process and followed by performing a role play showing the working mechanism of the process. On the other hand, role-play is a product of ‘play’, ‘games’ and ‘simulation’ (McSharry & Jones, 2000). In science education role-play may be seen as an interaction between these three components – either in combination or by themselves – and the child who ‘performs’ the activity, resulting in learning outcomes (McSharry & Jones, 2000).

Role-play is used in science teaching and learning – as with ‘active’, ‘experiential’ or ‘child-centered’ learning – where children are encouraged to be physically and intellectually involved in their lessons to allow them to both express their selves in a scientific context and develop an understanding of difficult concepts (Taylor, 1987). In addition, what is important about role plays and makes it effective is that it is based on a “play” (McSharry & Jones, 2000). Including the fun part in a session or a concept helps students to have long lasting memory and to simplify the difficult concepts.

Role play may be considered as an effective educational tool since first: it gives science teachers another option that can be used to link their work with (McSharry & Jones, 2000); second: it gives children a feeling of ‘ownership’ of their education (Danby & Upitis, 1988); third: many role-plays are based upon analogy, which helps children to conceptualize and this greatly increases learning (Lawson, 1993). As reported by Ross, Tronson, & Ritchie (2008), cellular respiration and metabolism are topics that are poorly understood by students, and reported as difficult concepts by teachers. Performing role plays is effective method to improve learning of glycolysis, Krebs cycle, and electron transport system.

According to studies, role plays were more effective when modeling was applied before. Modeling when used alone has been shown to be effective for short-term learning. However, it is insufficient for long-lasting behavior change if the target behavior does not produce rewards that sustain it. Modeling works well when it is combined with role-play and as reinforcement (Encyclopedia of Mental Disorders, 2017). Modeling in science education goal is to deepen the understanding of content and help solve novel problem. It is clear that modeling is used in science to support meaningful reform efforts. But still research should be done to identify how modeling is practiced in science and how these practices align with the aims of education (Svoboda & Passmore, 2011). In this research participant modeling was applied where the students wore t-shirts holding the name of the molecules, their functions, and the reactions they involve in. Thus, the students themselves were modeling the molecules of krebs cycle.

Purpose of the Study

The aim of this study is to investigate the effect of participant modeling followed by role play on grade eleven-scientific students’ achievement and motivation towards Krebs cycle in biology. Krebs cycle is formed of a series of chemical reactions; this causes confusion to students while learning it. In order to facilitate this concept and to help students to memorize molecules that intervene in the reactions and the information about each of the molecules, and to understand these reactions, it is proposed to introduce modeling technique followed by a role play. The basic technique is to associate things wanted to be remembered with images – not words – and then to mentally distribute those images spatially in a familiar location, such as a childhood home, school, or other familiar place. This is known as the method of loci, or "memory palaces" (Qureshi, Rizvi, Syed, Shahid, & Manzoor, 2014). From this point of view, the researcher planned to explain the concept of Krebs cycle by asking students to wear t-shirts that hold the name of the molecules and the reaction that include, information about the molecules explained and their role throughout the teaching/learning process. Then students were asked to model the reactions of Krebs cycle in their correct order as a role play. The study addressed the following research questions:

1. To what extent modeling followed by a role play affects students' achievement related to the concept of Krebs cycle?
2. To what extent modeling followed by role play as a new teaching method enhances students' motivation in biology classroom?

Method

Research Design

This study applied an action research. An action research refers to a wide variety of evaluative, investigative, and analytical research method designed to diagnose problems or weaknesses, whether organizational, academic, or instructional and help educators develop practical solutions to address quickly and efficiently (The Glossary of Education Reform, 2015).

Setting and Participants

A private school in Mount-Lebanon was selected based on its convenience in terms of location, time, and willingness of the biology teacher to participate in the study. The school serves students from kinder garden to grade twelve and implements the Lebanese curriculum. A total of nineteen students with ages ranging between 16 and 17 (N=19) enrolled in grade eleven scientific – it represents the second class in the secondary cycle of the Lebanese education system participated in the study. The researcher implemented the intervention in the presence of the teacher.

Instruments

To assess the effectiveness of modeling followed by role play the following instruments were utilized: pre and post achievement tests and a motivation questionnaire.

Pre Achievement Test in Biology

An instrument for assessing students' conceptual understanding in biology about cellular respiration and fermentation was developed by the researcher for the purposes of the study. The instrument consisted of two parts related to two lessons which were explained before the intervention (cellular respiration and fermentation). (Appendix A). For validity, a biology teacher (coordinator), with more than twenty years of experience, assessed the test concerning the difficulty level and clarity of questions, by which the questions' choices of the multiple choice questions were discussed and modified. Then, a pilot study was conducted on a sample of five grade eleven students, who were selected from another private school not a part of the sample. After modification, the pre-test constituted of fifteen multiple choice questions measuring memorization, understanding and application; and four direct questions (3 short answer questions measuring memorization and 1 calculation question measuring application). The questions covered different levels of bloom's taxonomy in order to identify knowledge, and higher cognitive skills (up to application).

Post Achievement Test in Biology

To assess the effectiveness of the teaching strategy (modeling followed by a role play), a post-test was developed by the researcher and administered on the same sample that was pre-tested. The questions were related to cellular respiration, fermentation and reactions of cellular respiration (glycolysis, Krebs cycle and electron transport chain). The post-test had the same layout as the pre-test and questions were constructed on the same cognitive level (memorization, understanding and application). For validity, two biology teachers (the original classroom biology teacher and another biology teacher), with more than ten years of experience, assessed the test concerning the difficulty level and clarity of questions (Appendix B). As a result, the post-test constituted of fifteen multiple choice questions measuring different cognitive skills (memorization, understanding and application), and one direct question about Krebs cycle measuring memorization and understanding.

Motivation Questionnaire

A science motivation questionnaire (SMQ) was adapted from Glynn & Koballa (2006) and was given to students after being modified by the researcher to meet students' language abilities. The motivation questionnaire can easily be used for all of science subjects, and it has good content validity and criterion-related validity. The questionnaire measured five factors: intrinsic motivation and personal relevance: the belief in the ability to succeed in certain situations and tasks (10 items: statements one, two, eleven, sixteen, nineteen, twenty two, twenty three, twenty five, twenty seven, and thirty), self-efficacy and assessment anxiety: how we think about and evaluate our selves (9 items: statements four, six, thirteen, fourteen, eighteen, twenty one, twenty four, twenty eight, twenty nine), self-determination: describes a person's overall sense of self-worth or personal value (5 items: statements five, eight, nine, twenty six), career motivation (2 items: statements ten, and seventeen), and grade motivation (4 items: statements three, seven, twelve, fifteen, twenty). The thirty questions followed a Likert scale of five levels from strongly agree to strongly disagree. For validity, a pilot study was conducted on a sample of five grade eleven students, who were selected from another private school not a part of the sample. The pilot test was conducted for three purposes: first to check for clarity of items in the questionnaire, second to check the format of the questionnaire, and third to check the time needed to complete the test. The researcher set the time to complete the test, asked the students for their opinion on the clarity of the questionnaire design, layout, and font size. The final version of the questionnaire was checked by an English instructor (sworn translator) (see Appendix C).

Intervention Procedure

The duration of the study was a total of four non-successive weeks, during the second semester of the school year. A total of six sessions were given throughout the study. During the intervention the researcher used t-shirts for modeling Krebs cycle molecules. The aim of using t-shirts is to help students memorize the different molecules used in Krebs cycle. The t-shirt models can help students of different learning styles-reading/writing, auditory, kinesthetic, and visual- to acquire the knowledge. Information defining the molecules are written on the front side of the modeling t-shirts, this can help reading/writing learners to acquire the knowledge, the reactions are drawn on the back of the t-shirts to help visual learners to acquire the knowledge, wearing the t-shirts to represent the molecules can help kinesthetic learners to intervene in the reactions and acquire the knowledge and through modeling students are asked to explain orally each molecules' structure, characteristics, role and the reactions it intervene in them, this can help auditory learners to get the knowledge too.

At the end of modeling that took three sessions the students were asked to apply a role play. The aim of applying the role play was to connect and relate the molecules to each other. The role play required students to act and represent the molecules that they modeled, through acting students were asked to move and stand in the correct place in the cycle and explain to their friends their characteristics. The time line is represented in Table 1.

Table 1. Summary for the Intervention Period

Week number	Period number	Date	Plan
Week 1	Period 1	12/4/2017	-
	Period 2	13/4/2017	Pre-test and questionnaire implementation
Spring vacation			
Week 2	Period 1	26/4/2017	Explanation of the lesson (modeling)
	Period 2	27/4/2017	Explanation of the lesson (modeling)
Week 3	Period 1	3/5/2017	Explanation of the lesson (modeling)
	Period 2	4/5/2017	-
Week 4	Period 1	10/5/2017	Applying the role play
	Period 2	11/5/2017	Post-test and questionnaire implementation

Data Analysis

The computer program SPSS was used to quantify the data collected via the pre and post achievement tests and the pre and post-motivation questionnaires. The achievement tests results were coded and entered into the SPSS computer program to be analyzed and compared. The information and all questions of the questionnaire were also coded and entered into the SPSS computer program. The questionnaire items were coded and categorized, the questionnaire was designed on a likert scale from one (strongly agree) to five (strongly disagree) and the number that student ticked was entered as it is. Students' responses were coded as 1 referring to the highestlevel attitude and 5 referring to the lowest level attitude towards biology. In order to examine the achievement of the students throughout the intervention, the researcher compared the means of the pre achievement test and post- achievement test using paired t-test on the SPSS computer program. A paired t-test is used for comparing two means of data from two related samples before and after intervention on the same participants. If the paired t-test results showed p value less than 0.05 then the test is considered to be significant. The standard deviation is calculated just to quantify the variation/dispersion of the data, thus it will be identified if outliers are present or not.

In addition, the researcher compared the median of the pre and post- achievement tests. The median is the value separating the high half of the data sample from the lower half. Also, the mode (the value that appears most often) of the pre and post-achievement test was identified in order to check which grade appeared most, and it has been compared between the two tests. In order to measure the internal consistency of the pre and post-achievement tests, Cronbach alpha was calculated too. If Cronbach alpha is greater than or equal to 0.6 the data is considered to be reliable. Concerning the pre and post-motivation questionnaires, the mean ($\bar{x}$=Ɛx/n: the mean is the average of a data sample) for every statement was calculated, the small values (between 1 and 2) shows high positive attitude towards motivation while large values (between 3 and 4) shows high negative attitude towards motivation. The standard deviation (SD= Ɛ$(x-\bar{x})^2$/n-1) is calculated just to quantify the variation/dispersion of the data, thus it will be identified if outliers are present or not. A low standard deviation indicates that the data points tend to be close to the mean, while a high standard deviation indicates that the data points tend to be spread over wide range.In addition, the researcher calculated the median for each item (statement) of the pre and post-motivation questionnaire for relating to how meaningful biology classes were to students' overall life and how much preparation/studying they had to go through when preparing for class.

Ethical Issues

Ethical Considerations can be specified as one of the most important parts of the research. The researcher took into consideration the ethical issues, the school administration and participants were informed about the research topic which was explained and discussed with them, communication between the researcher and students, teachers and principle was with total honesty and transparency concerning the timing of the whole intervention and the requirements. One of the researcher's priorities was not to subject students to harm at all levels (educational and personal). Anonymity of individuals participating in the research was ensured by which students weren't obliged to write their names on the tests, instead codes were given to the students to be used in tests.

Results

Results of the Pre-Achievement Test

The percentage of correct answers per each cognitive level was measured in the pre-achievement test. The results are shown in Table 2.

Table 2. The Percentage of Correct Answers per Cognitive Level of Questions of the Pre-test

Question cognitive level	Average percentage of correct answers per cognitive level
Memorization	49.35%
understand	51.06%
Application	77.75%

Results of the Post-Achievement Test

The percentage of correct answers per each cognitive level was measured in the post-achievement test. The results are shown in Table 3.

Table 3. The Percentage of Correct Answers per Cognitive Level of Questions of the Post-test

Question cognitive level	Average percentage of correct answers per cognitive level
Memorization	51.225%
understand	30.5%
Application	100%

Comparison between the Results of the Pre and Post-Achievement Tests

In order to identify any significant difference between the pre and post-achievement tests a paired t-test was done using SPSS computer program the results are shown in Table 4.

Table 4. The Significance of the Paired t-test of the Pre/post-achievement Tests

	Mean	N	Standard deviation	Std. Error mean
Pre-test grades	12.8676	17	2.17607	0.52778
Post-test grades	15.7059	17	3.10271	0.75252
Pretest grades- posttest grades			0.001 **(Sig. 2-tailed)**	

The median and mode of the pre and post-achievement tests were calculated using SPSS computer system. The results are shown in Table 5.

Table 5.The Median and Mode of the Pre and Post-achievement Tests

		Pre-test grades	Post-test grades
N	**valid**	18	18
	missing	1	1
Median		13	16
Mode		15.5	15

In order to measure the internal consistency of the pre and post- achievement tests, Cronbach alpha was calculated too using SPSS computer system. Table 6 presents the results of Cronbach alpha.

Table 6. Cronbach's Alpha Value to Show Reliability

Cronbach's alpha	Cronbach's alpha based on standardized items	N of items
0.636	0.663	2

Table 7 presents the summative means and standard deviations for the five factors that the motivation questionnaire relies on.

Table 7.The Summative Means and Standard Deviations for the Five Factors of the Motivation Questionnaire

Question number	factors	motivations questions	Means	Standard deviation
5	**self-determination**	if I find difficulty in learning science I work hard to understand	2.26	1.098
8		I learn science with great interest and spare no effort for such goal	3.11	1.243
9		I employ different approaches to establish that I learn the science well	2.37	1.065
26		I prepare well for science tests and laboratory work	2.32	1.108
		Total	**2.515**	**1.1285**
4	**self-efficacy and assessment anxiety**	it makes me anxious about my performance in science exam	2.84	1.385
6		before a science test I become anxious	3.58	1.071
13		it makes me worried to think of a weak performance in the science exam	2.37	1.383
14		I try to perform well in science evaluation in comparison to other students	2.53	1.264
18		I do not like to even think about science evaluation	3.26	1.522
21		I can perform better in science projects, developments or labs	1.74	0.806
24		I have confidence in my abilities that will perform well in science exam	1.79	0.713
28		I am sure of my capabilities and competencies in the science subject	2.21	0.918
29		I feel positive that I can achieve "A" Grade in science subject	2.05	1.42
		Total	**2.4855**	**1.164**
1	**intrinsic motivation and personal relevance**	I have pleasure in science learning	1.53	0.697
2		my personal goals and objectives associate with my science learning	2.42	1.121
11		I consider carefully how science learning can support my profession	2.21	1.357
16		to me high grades in science is not as significant to me as learning science subject	2.47	1.124
19		how I will employ the science which I study in daily lives and in future is significant	2.28	1.018
22		studying science is interesting to me	2	1.247
23		the science has realistic worth for me	2.05	1.026
25		all the science learning is associated to my existence	2.11	1.049
27		I like science learning since it is a challenge to me	2.68	1.057
30		when I understand science, I feel successful	1.129	0.507
		Total	**2.0879**	**1.0203**
10	**career motivation**	the science I learn assists me in realizing distinguished career	2.32	1.003
17		how science will be useful to me is considerable	2.11	0.937
		Total	**2.215**	**0.97**
3	**grade motivation**	it always concerns me that other students perform better in science	3.05	1.224
7		it is essential and valuable for me to get high	2.05	1.268
12		I look for better achievement in science subject than other students	2.32	1.057
15		It seriously concern about my science performance and how its influence my overall grade	2.32	0.885
30		when I understand science, I feel successful	1.129	0.507
		Total	**2.1738**	**0.9882**

Results of the Post-Motivation Questionnaire

Table 8 presents the summative means and standard deviations for the five factors that the motivation questionnaire relies on.

Table 8. The Summative Means and Standard Deviations for the Five Factors of the Motivation Questionnaire

Question number	factors	motivations questions	Means	Standard deviation
5	**self-determination**	if I find difficulty in learning science I work hard to understand	2.37	1.257
8		I learn science with great interest and spare no effort for such goal	2.58	0.961
9		I employ different approaches to establish that I learn the science well	2.32	0.749
26		I prepare well for science tests and laboratory work	2.53	1.073
		Total	**2.45**	**1.01**
4	**self-efficacy and assessment anxiety**	it makes me anxious about my performance in science exam	2.63	1.257
6		before a science test I become anxious	3.05	1.079
13		it makes me worried to think of a weak performance in the science exam	2.42	1.261
14		I try to perform well in science evaluation in comparison to other students	2.32	1.108
18		I do not like to even think about science evaluation	3.47	0.841
21		I can perform better in science projects, developments or labs	2.00	0.943
24		I have confidence in my abilities that will perform well in science exam	2.00	0.816
28		I am sure of my capabilities and competencies in the science subject	2.42	0.961
29		I feel positive that I can achieve "A" Grade in science subject	2.16	0.898
		Total	**2.49**	**1.018**
1	**intrinsic motivation and personal relevance**	I have pleasure in science learning	1.68	0.82
2		my personal goals and objectives associate with my science learning	2.32	0.671
11		I consider carefully how science learning can support my profession	2.37	0.831
16		to me high grades in science is not as significant to me as learning science subject	2.37	1.212
19		how I will employ the science which I study in daily lives and in future is significant	2.47	0.697
22		studying science is interesting to me	1.89	1.1
23		the science has realistic worth for me	2.32	1.003
25		all the science learning is associated to my existence	2.47	1.073
27		I like science learning since it is a challenge to me	2.26	0.933
30		when I understand science, I feel successful	1.74	0.733
		Total	**2.189**	**0.9073**
10	**career motivation**	the science I learn assists me in realizing distinguished career	2.53	0.905
17		how science will be useful to me is considerable	2.00	0.745
		Total	**2.265**	**0.825**
3	**Grade motivation**	it always concerns me that other students perform better in science	2.74	1.098
7		it is essential and valuable for me to get high	2.21	1.182
12		I look for better achievement in science subject than other students	2.42	1.017
15		It seriously concern about my science performance and how its influence my overall grade	2.11	0.937
30		when I understand science, I feel successful	1.74	0.733
		Total	**2.244**	**0.9934**

Comparison between Results of the Pre and Post-Motivation Questionnaires

Table 9 presents a comparison of the summative means of the five factors that the pre and post-motivation questionnaires relies on.

Table 9. A Comparison of the Summative Means of the Five Factors of the Pre and Post-motivation Questionnaires

Factors	Pre-motivation test	Post-motivation test
self-efficacy and assessment anxiety	2.48	2.49
intrinsic motivation and personal relevance	2.0879	2.189
self-determination	2.515	2.45
career motivation	2.215	2.265
Grade motivation	2.1738	2.244

Discussion

This section presents the significance of the results presented in the previous part. The intervention was performed to identify the effect of modeling followed by a role play on improving grade eleven scientific students' memorization abilities, understanding biological reactions, motivation towards biology classes. In the following sections we will discuss the results based on the research questions and relate the findings to similar studies.

To what extent modeling followed by a role play affects students' achievement related to the concept of Krebs cycle?

Students need to experience new teaching strategies to help them, in the first place, to improve their academic achievement, and in the second place, to make biology classes more interesting and motivating. Students always look for improving their achievement. Modeling technique was used to help students memorize the names and formulas of the molecules, identify their structure, and their role within Krebs cycle.

The results, after implementing modeling followed by role play, showed high significance (sig= 0.001) at the level of achievement, this indicates that the intervention modeling through t-shirts, followed by a role play-enhanced students' achievement. The mean of the pre-achievement test was 12.8676 while that of the post-achievement test was 15.705. In addition, the median (the grade that splits the data in half) increased, it was 13 in the pre-achievement test and became 16 in the post achievement test.

Our results are in agreement with in other showing that role play affected students' achievement and motivation positively. According to these studies, learning activities using modeling and role play enhance emotions and creativity in students and improve their acquisition and recall of new information (Worren, 1997; Taylor, 1997; Odom &Kelly, 1998; Ross et al, 2005; Ross, Tronson, & Ritchie, 2008). In addition, Ross, Tronson, & Ritchie (2008), reported that "role play creates a "mental picture" of molecular or submicroscopic processes and enables the students to link more readily the macroscopic and molecular (submicroscopic) scale".

The researcher analyzed the items of the questions in the pre-achievement test to identify which cognitive skill (memorization, understanding, and application) was affected most. Results showed that students' achievement within questions related to memorization has improved. While students' achievement within questions related to understanding was affected negatively. In the pre-achievement test, a total of nineteen questions were given to students, twelve of them were questions related to memorization, five questions related to understanding and two questions related to application. The predominant cognitive skill that was measured within the pre and post-achievement tests was memorization. Similarly in the post-achievement test, a total of 16 questions were given to students, ten questions related to memorization, four questions related to understanding, and two questions related to application.

According to the results, questions related to memorization and application directed the results of the tests. The increase in students' achievement within questions related to memorization and application (the total percentage of correct answers for the memorization cognitive level was 49.35% in the pre-test becomes 51.225% in the post test and for the application cognitive level was 77.75% becomes 100% in the post test) caused an increase in their achievement within the whole achievement test. Although students' achievement within questions related to understanding was affected negatively (the total percentage of correct answers for the understanding cognitive level was 51.06% in the pre-test becomes 30.5% in the post test), but this didn't cause a decrease in their achievement within the whole achievement test. The decrease in students' achievement in questions related to understanding might be due to the fact that it was hard for them to relate the ideas stated on the t-shirts all together. In addition, students weren't prepared well for the role play, during the role play students should relate the whole ideas together. This might have affected students' performance in the questions related to understanding.

To what extent modeling followed by role play as a new teaching method enhances students' motivation in biology classroom?

Achievement is important but nowadays motivation is considered to be as important as achievement. Students are finding difficulties in adapting to the old teaching strategies in the presence of technology. So teachers should use new teaching strategies that are suitable for students' interests. New teaching methods can include technology, or can attract students through engaging them within the teaching/learning process. "In higher education, student engagement and student satisfaction have always been prominent features, but have now come to the fore" (Mogra, 2012, p.4). The researcher used modeling followed by a role play as new teaching methods. When students are the ones who are modeling the molecules this makes them more engaged, teaching/learning strategies that engage students result in a greater number of students using metacognitive skills to understand abstract concepts (as cited in Ross, Tronson, & Ritchie, 2005). To check students' motivation through the intervention, the researcher used a motivation questionnaire that was adapted to meet students' language abilities (Glynn & Koballa 2006).

Results showed that the most motivating factor is intrinsic motivation and personal relevance with means

(2.0879) in the pre-test and (2.189) in the post-test. No significant changes at the level of self-efficacy, assessment anxiety and career motivation factors. While concerning self-determination, although it remained the least motivating factor but it showed a slight decrease. Whereas, concerning grade motivation factor, results showed that it was affected negatively with a slight increase in its mean. Although no significant change was detected, but most of the means, that were calculated in the pre and post-motivation questionnaires, were ranging between 1.5 and 2.5. The means that tend to be close to 1 represent high motivating items (strongly agree), the means that tend to be close to 2 represent motivating items (agree), while that tend to be close to 3 show indifferent attitude towards the items. And the means that tend to be close to 4 and 5 represent non-motivating items. Results showed in the pre-test, students find pleasure in learning biology, and they feel pleasure when they understand biology. Students' attitude towards grade motivation is negative. Results didn't change in the post-test. Twenty eight of the thirty items of the post-motivation questionnaire have means ranging between 1.5 and 2.5. While only 2 items have means greater than 3. This indicates that students are motivated towards biology sessions, before and after the intervention.

One of the obstacles that might have affected students' motivation is that they didn't wear the t-shirts through the whole implementation as it was planned; this reduced their motivation and the fun part of the intervention. In addition, one of the most important problems we faced during the intervention was that the students didn't experience before new teaching methods (modeling/ role plays). Similarly in the role play the students were required to explain the molecules he/she has modeled, but due to lack of experience in presenting and preforming role plays, the rehearsal required guidance from the instructor, where students weren't able to know their role according to their places in the cycle and function too.

Although role plays have many advantages, but some students may be reluctant to participate and others may feel intimidated, in addition some implementation problems may occur, and factors such as time and space may affect its effectiveness (Kerr, Troth, & Pickering, 2003; McGregor, 1993; Mogra, 2012). Such limitations affected students' motivation in the study.

Conclusion

This action research explored the effect of modeling followed by a role play on grade eleven scientific students' achievement at the level of memorization and understanding, and motivation. Krebs cycle is made up of series of chemical reactions, where students usually find difficulties in memorizing them. Data was collected using many tools: pre and post achievement tests to measure the cognitive level of memorization, understanding and application, pre and post motivation questionnaire to measure five factors: intrinsic motivation and personal relevance, self-efficacy and assessment anxiety, self-determination, career motivation and grade motivation.

The research followed a three step process, step one lecture, step two participant modeling, and step three a role play. According to research it was found that combining the two teaching methods modeling and role play help in having long-lasting behavior change (Encyclopedia of Mental Disorders, 2017). Data presented in the pre and post achievement tests were compared and analyzed to show that implementing modeling followed by a role play enhanced students' achievement. Results showed also that students' memorization abilities improved. In addition, results related to questions that tackled understanding cognitive skill were negative. Some obstacles were behind having such a result. Although solving questions related to understanding were affected negatively through the intervention, but the main aim of the intervention was to improve students' memorization of the chemical reactions and it was achieved. This justifies why the results of the pre and post tests were significant. At the level off motivation, the results showed that before and after the intervention intrinsic motivation and personal relevance was the most effective motivator. Although no significant change had occurred in concern of motivation in general, motivation is still considered to be positive (ranging between 1.5 and 2.5) and no negative effect was shown (absence of means ranging between 3.5 and 5).

Recommendations

Having an exploratory and interpretive nature this study raises a number of opportunities for future research, both in terms of theory development and concept validation. More research will in fact be necessary to refine and further elaborate our novel findings.

First, our study could be extended to search for new teaching methods and strategies (other than modeling and role play) that can be implemented to explain the concept of cellular respiration and Krebs cycle.

Second, new research could be done by linking the two difficult concepts photosynthesis and cellular respiration using modeling and role play to help students identify the inter relationship between the different micro-processes that occur within the cell.

The methodology implemented in this research could also be used to generate a number of research questions for further empirical testing using a broader sample:

- Is there a statistical correlation between students' learning styles and performing modeling and role play strategies?
- Would performing a sum up schema after modeling and role play help students overcome their misconceptions related to cellular respiration and Krebs cycle?

The study could also be extended in a comparative way. For example, explain Krebs cycle within different teaching strategies (lecture only, reading articles, using technology, modeling and role play), and perform a comparative analysis to identify the best method to be implemented in explaining this topic.

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Appendix A. Pre-achievement Test

I- Circle the correct answer(s). (You can choose more than one answer).

- The aim of cellular respiration is to produce:
  a) Oxygen gas
  b) Carbon dioxide
  c) Alcohol
  d) Energy
- Bacteria are microscopic single-celled small organisms. To function they need
  a) Food molecules and water.
  b) Food molecules, but do not need water.
  c) Water, but they do not need molecules from food.
  d) No water, and no food molecules
- The energy produced from the alcoholic fermentation of 1 mole of glucose is
  a) 272 KJ
  b) 468 KJ
  c) 138 KJ
  d) 1264 KJ
- Lactic fermentation occurs when ______________ is present in the medium of the microscopic organisms.
  a) Galactose
  b) Lactose
  c) Glucose and galactose
  d) Fructose
- Cellular respiration occurs in
  a) Animal and plant cells
  b) All eukaryotic cells
  c) Bacterial cells only
  d) All living cells
- Respiration _____, and cellular respiration ______.
  a) Uses glucose . . . is intake of O2
  b) Produces glucose . . . produces oxygen
  c) Is gas exchange . . . produces ATP
  d) Produces ATP . . . is gas exchange
  e) Produces CO2 . . . is intake of O2
- Which of the following are products of cellular respiration?
  a) ATP and carbon dioxide
  b) Glucose and carbon dioxide
  c) Oxygen and ATP
  d) Oxygen and carbon dioxide
  e) Oxygen and glucose

- The usefulness of the process fermentation as a means of deriving energy is limited because it
    a) Cannot generate enough ATP
    b) produces too much lactic acid or alcohol
    c) produces toxic substances
    d) uses more energy than it produces
- Which of the following is **not** a product of fermentation?
    a) CO_2
    b) O_2
    c) Ethanol
    d) Lactate
    e) All of the above are products of fermentation
- Which of the following organisms carries out cellular respiration?
    a) A corn plant
    b) A dog
    c) A yeast
    d) A bacterium
    e) All of the above
- Which of the following overall equation represent(s) fermentation that occur(s) in yeast cells?
    a) $C_6H_{12}O_6$ -----> 2 pyruvate + 2 ATP
    b) 6 CO_2 + 6 H_2O + energy -----> $C_6H_{12}O_6$ + 6 O_2
    c) $C_6H_{12}O_6$ + 6 O_2 -----> 6 CO_2 + 6 H_2O + energy
    d) $C_6H_{12}O_6$ -----> 2 lactate + 2 ATP
    e) $C_6H_{12}O_6$ -----> 2 alcohol + 2 CO_2 + 2 ATP
- Which of the following fermentation methods can occur in animal skeletal muscles?
    a) lactic fermentation
    b) alcohol fermentation
    c) 2 kinds of fermentation
    d) Acetate fermentation
- Upon acetate fermentation of 6 moles of glucose, ______________ are produced.
    a) 138 kJ
    b) 272 KJ
    c) 828 KJ
    d) 1632 KJ
- During aerobic cellular respiration, which reactant originates from the digestive system?
    a) Oxygen
    b) Carbon dioxide
    c) ATP
    d) Water
    e) Glucose

- The term anaerobic means
  - a) Without bacteria.
  - b) Without CO2.
  - c) Without ATP.
  - d) Without O2
  - e) With O2.

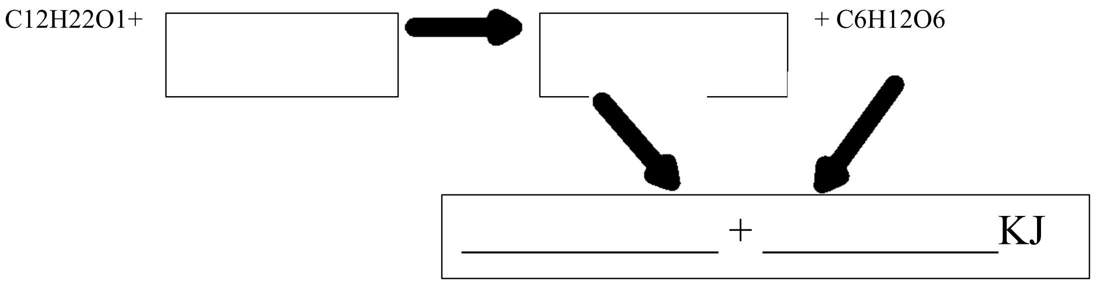
II-

a. Write the reaction of the alcoholic fermentation.

b. Calculate the energy produced by 7 moles of glucose.

III- Write the reaction of the acetate fermentation.

VI- Complete the following with the suitable molecule.

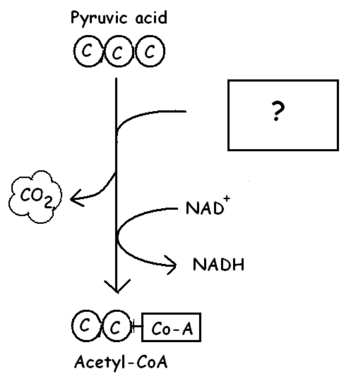


Appendix B. Post-achievement Test

I. Circle the correct answer(s). (You may choose more than one answer).

1. At the end of cellular respiration we obtain:
   a) ATP
   b) Carbon dioxide
   c) Ethanol
   d) Water
2. Cellular respiration process
   a) Degrades completely organic matter
   b) Releases a small quantity of energy
   c) Produces organic residues
   d) Uses a large quantity of energy
3. Which of the following is produced during Krebs cycle
   a) NADHP
   b) NADH
   c) $FADH_2$
   d) ATP
4. A cell culture was supplied with radioactively labeled O2. The cells were monitored. In a few minutes the radioactive oxygen atoms were present in which of the following compounds:
   a) carbon dioxide
   b) NADH and FADH2
   c) water
   d) ATP
   e) lactic acid
5. Which pathway for aerobic cellular respiration is located in the cytoplasm of the cell?
   a) glycolysis
   b) Krebs cycle
   c) electron transport system
   d) fermentation
6. Which of the following pathways will use coenzyme A during aerobic cellular respiration?
   a) glycolysis
   b) transition reaction
   c) Krebs cycle
   d) electron transport system
   e) fermentation
7. Between glycolysis and the citric acid cycle
   a) Pyruvate is oxidized while a molecule of NAD+ is reduced to NADH.
   b) Coenzyme A is cleaved off of the four-carbon compound.
   c) A carbon atom is added to make a four-carbon compound.
   d) None of the choices are correct.

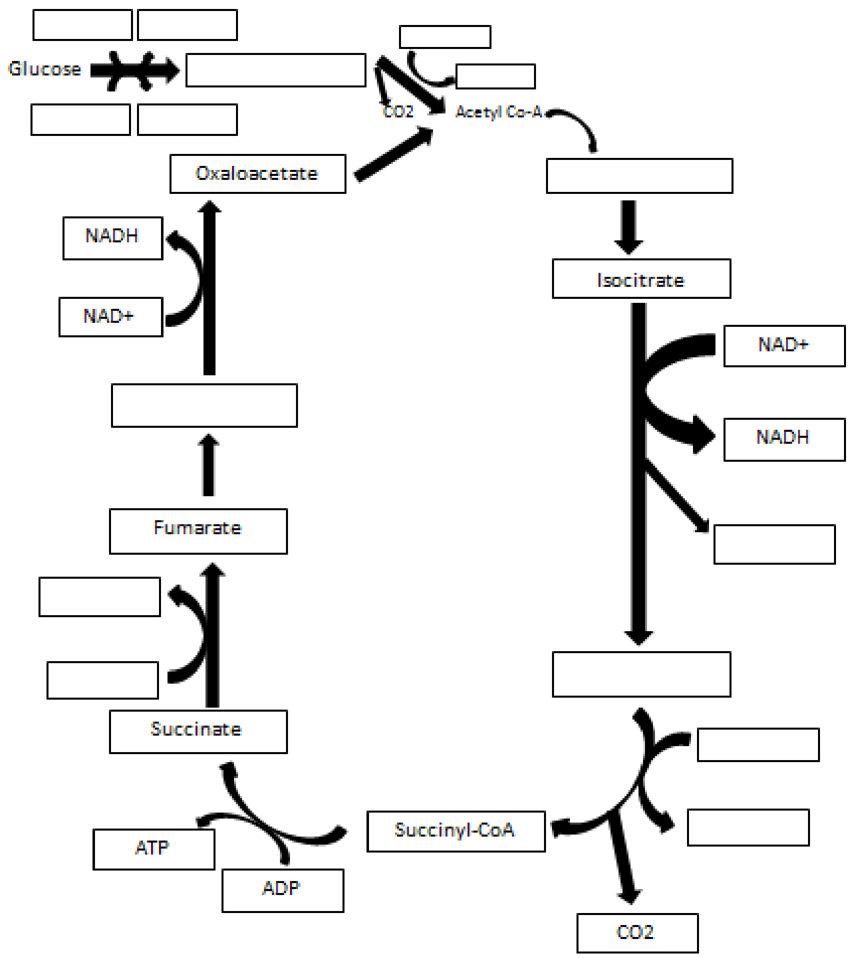
8. At the end of the citric acid cycle, most of the energy remaining from the original glucose is stored in
   a) FADH2
   b) CO2.
   c) Pyruvic acid.
   d) ATP.
   e) NADH.
9. How many ATP are produced from by the aerobic oxidation of one mole of glucose
   a) 8
   b) 30
   c) 38
   d) 36
10. Name the molecule that joins in this reaction to make Acetyl-CoA

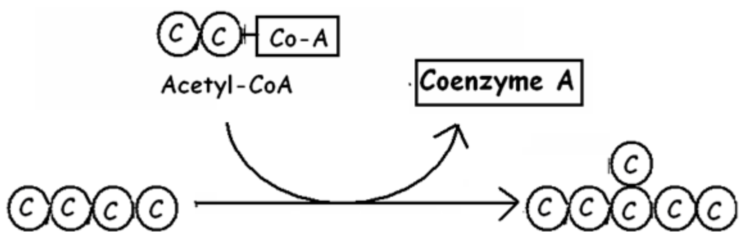


   a) ATP
   b) $NADP^+$
   c) Coenzyme A
   d) citric acid
11. If oxygen is present, what will happen to the NADH produced in this reaction?
   a) Its electrons will enter the Electron transport chain
   b) It will donate its H+ ions to make glucose
   c) It will join with ATP to make citric acid
   d) It will join with oxygen to make CO_2
12. The amount of ATP from 7 moles of glucose is
   a) 38
   b) 252
   c) 266
   d) 36
13. Which of the following shows the correct sequence during cellular respiration?
   a) Electron transport chain → glycolysis → Krebs cycle
   b) Glycolysis → Electron transport chain → Krebs cycle
   c) Krebs cycle → Electron transport chain → glycolysis
   d) Glycolysis → Krebs cycle → Electron transport chain
14. Name the 6 carbon molecule that forms when Acetyl-CoA joins its 2 carbons to a 4 carbon molecule during the Krebs cycle.
   a) ATP
   b) pyruvic acid
   c) glucose
   d) citric acid

15. Pyruvate
    a) Is the molecule that starts the citric acid cycle
    b) Is the end product of electron transport chain
    c) Is a six-carbon molecule.
    d) Forms at the end of glycolysis

II- Complete the cycle with the suitable molecule





Appendix C. Motivation Questionnaire

	motivations questions	strongly agree	agree	indifferent	disagree	strongly disagree
1	I have pleasure in science learning	□	□	□	□	□
2	my personal goals and objectives associate with my science learning	□	□	□	□	□
3	it always concerns me those other students perform better in science	□	□	□	□	□
4	it makes me anxious about my performance in science exam	□	□	□	□	□
5	if I find difficulty in learning science, I work hard to understand	□	□	□	□	□
6	before a science test I become anxious	□	□	□	□	□
7	it is essential and valuable for me to get high grades	□	□	□	□	□
8	I learn science with great interest and spare no effort for such goal	□	□	□	□	□
9	I employ different approaches to establish that I learn the science well	□	□	□	□	□
10	the science I learn assists me in realizing distinguished career	□	□	□	□	□
11	I consider carefully how science learning can support my profession	□	□	□	□	□
12	I look for better achievement in science subject than other students	□	□	□	□	□
13	it makes me worried to think of a weak performance in the science exam	□	□	□	□	□
14	I try to perform well in science evaluation in comparison to other students	□	□	□	□	□
15	It seriously concern about my science performance and how its influence my overall grade	□	□	□	□	□
16	to me high grades in science is not as significant to me as learning science subject	□	□	□	□	□

17	how science will be useful to me is considerable	□	□	□	□	□
18	I do not like to even think about science evaluation	□	□	□	□	□
19	how I will employ the science which I study in daily lives and in future is significant	□	□	□	□	□
20	I am personally concerned if I do not get comprehend the science well and weak in understanding	□	□	□	□	□
21	I can perform better in science projects, development or labs	□	□	□	□	□
22	studying science is interesting to me	□	□	□	□	□
23	the science has realistic worth for me	□	□	□	□	□
24	I have confidence in my abilities that will perform well in science exam	□	□	□	□	□
25	all the science learning is associated to my existence	□	□	□	□	□
26	I prepare well for science tests and laboratory work	□	□	□	□	□
27	I like science learning since it is a challenge to me	□	□	□	□	□
28	I am sure of my capabilities and competencies in the science subject	□	□	□	□	□
29	I feel positive that I can achieve "A" Grade in science subject	□	□	□	□	□
30	when I understand science, I feel successful	□	□	□	□	□
31	how you make memorizing easy while studying					
32	while learning and studying biology what are the difficulties / obstacles you face					