Effectiveness of Visualization on Problem Solving and Experimental Tasks in Learning Heat and Temperature for Grade Nine

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Abstract

This study examined the effectiveness of visualization on problem solving and experimentation tasks in learning heat and temperature. Quasi-experimental research design was used with 109 total number of ninth grade students. The instruments were achievement test, Questionnaire and interview. The overall results show that achievement scores of learners in experimental group were better than those in the control group (t-test, $p < 0.05$). Comparison of male and female students of experimental group, ($M = 2.97$, $SD = .9$) at $t = .32$, $p= .005$ and ($M =3.4$, $SD =3.7$) at $t = 5.1$, $p = .000$ respectively. There was significant improvement for male students of the experimental group compare to the female counterparts. Despite there was significance correlation between achievement score and performance assessment scores for problem solving tasks no significance correlation.

Keywords: Systematical, creating scientific meanings.

Resumen

Este estudio examinó la efectividad de la visualización en la resolución de problemas y las tareas de experimentación en el aprendizaje del calor y la temperatura. El diseño de investigación cuasiexperimental se utilizó con 109 número total de estudiantes de noveno grado. Los instrumentos fueron prueba de rendimiento, cuestionario y entrevista. Los resultados generales muestran que los puntajes de rendimiento de los alumnos en el grupo experimental fueron mejores que los del grupo de control (prueba t, $p <0.05$). Comparación de estudiantes masculinos y femeninos del grupo experimental, ($M = 2.97$, $SD = .9$) en $t = .32$, $p = .005$ y ($M = 3.4$, $SD = 3.7$) en $t = 5.1$, $p = .000$ respectivamente. Hubo una mejora significativa para los estudiantes varones del grupo experimental en comparación con las contrapartes femeninas. A pesar de que hubo una correlación significativa entre el puntaje de logro y los puntajes de evaluación de desempeño para las tareas de resolución de problemas, no existe una correlación significativa.

Palabras clave: Estrategias para desarrollar habilidades, Arduino y Tracker, Enseñanza en ingeniería.

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I. INTRODUCCIÓN

The recent emergence of modern audio-visual media and information technologies, their applications in teaching and learning raise challenges and opportunities [1]. According to this document there is a basic question to be considered what instrument could be more relevant and more useful that comprehensively improving the actual ability so that the students can obtain systematical experimental theoretical techniques and complete skills? According to Vygotsky as it mentioned in the document [1], knowledge acquisition and conceptual change take place through a process of formulation, reformulation, and reinterpretation of knowledge. The learner is an active constructor of his/her own knowledge, and the process of knowledge acquisition is greatly assisted by interactions with peers and in particular with a teacher acting at the zone of proximal development.

Visualization is to do with Visio-spatial materials because visualization is the ability to manipulate visual patterns and identify mental images cited in [2]. It will be extremely difficult to make a visualization that pleases and facilitates learning for all students in a class [3]. Whenever a student engage with problem representation (visualization) and problem solution what may happen is if problems differ in terms of structure, complexity, and context, then so too the kind of problem solving processes [4]. Based on the work of [5] physicists are able to look at problems in different perspectives, with each perspective providing different types of information about the problem situation. Problem situation can be thought in terms of words, diagrams, graphs, and equations.

Physics should deal with ideas in the form of models, metaphors, or analogies in physical or experiential models.

The article of [6] demonstrate that the interaction of students with modeling software was instrumental in creating scientific meanings. A well-designed experimental task will show the basic physical quantities (heat quantity, heat transfer, and change of state) in a simple form, helpful for students to establish a physical image of abstract concepts, contributing to understanding and mastering of the concept and laws. Likewise, well-designed science laboratory can provide the sorts of experiences necessary to correct misconceptions and to develop useful physical insight. It is one of the few places where students can actually involve themselves in the processes of science: students gain first-hand understanding of physical phenomena, construct for themselves the theories needed to comprehend the physical world and express their own questions, further engaging them in the learning process [7]. This study based on constructivist principles attempts to facilitate problem solving and experimentation process in the physics classroom and physics laboratory by using visualization tools during problem solving activities and computer simulations during experimentation activities in learning heat and temperature for grade nine students.

A. Statement of the problem

We can find a fruitful way to alter the way most science courses are taught: to begin with we should emphasize on what students know, continue with what they can learn by arranging their interaction with the physical world around them, and connect this learning to the underlying principles of scientific knowledge. An instructional practice that has emerged over the last two decades began with what is commonly termed the personal constructivist model of learning, or simply personal constructivism. A personal constructivist model of learning assumes the existence of learners' conceptual schemata and the active application of these in responding to and making sense of new situations.

The traditional teacher dominated teaching method tend to suppose that one way of transmission of knowledge is possible in all situations. This assumption by itself has shortcomings it usually focuses on content coverage without the necessary effort to connect different physics concepts together, with no attempt to develop critical thinking or problem-solving skills. Not only do students not have an opportunity to form their own ideas, they rarely get a chance to work in any substantial way at applying the ideas of others to the world around them. This study tries to find the way out from such pitfalls of our traditional method that is the dominant approach in our physics classroom and laboratory seeking better result.

B. Objective of the research

The general objective of this study is to examine the effectiveness of visualization on problem solving and experimentation tasks in learning heat and temperature. The specific objectives are to address the research questions.

C. Research questions

1. Are there any significant differences on problem solving-skills as a result of Visualization strategies?
2. Are there any significant differences on experimentation-skills as a result of visualization simulations?

D. Significance of the study

In the 21st century due to emergence of modern audio-visual media and information technologies our classrooms and laboratories could meet the demand of our students as well as their parents and the society at large. Therefore, the result of this study is important for curriculum material preparations so that the duty of the teacher becomes technology supported. As a result of this students are benefited for better performance in problem solving and experimentation tasks which has direct impact on their academic achievement.

II. METHODOLOGY

The theoretical foundation of this study is schema/mental model theory. Schema is a complex representational knowledge structure that includes declarative and procedural knowledge related to a specific topic or process. In short schemas refers to relevant prior knowledge in long memory [8]. If different knowledge representations foster different skills and levels of conceptual understanding, one should also ask whether they produce different level of cognitive load. For instance, presenting a visual model of a scientific system in addition to a verbal explanation of how the system works have been found to promote student' problem solving as well as experimentation transfer skills.

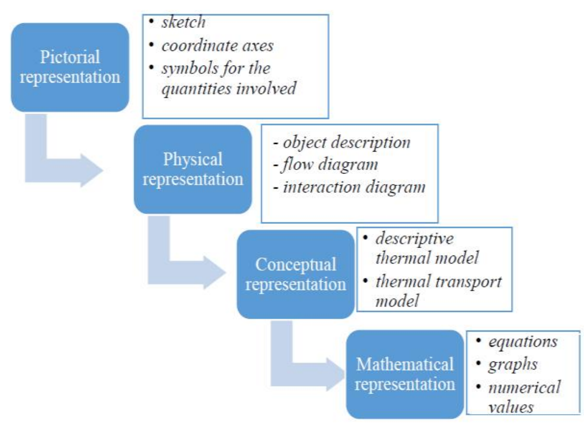

FIGURE 1. Schematic depiction of visualization assisted teaching method for problem solving task.

A. Experimental intervention during problem solving task

The teacher guide was prepared for this research purpose which discusses the tasks to be performed through visualization assisted teaching method on topics about heat quantity, heat transfer and change of state. The teacher for experimental group was trained how to use the intervention in the guide. The intervention is visualization assisted teaching depicted by this schematic model.

B. Experimental intervention during experimental task

The teacher guide was prepared for this research purpose which discusses the tasks to be performed through simulation-based teaching method on three experiments about calorimetric, heat of fusion, heat of vaporization. The teacher for experimental group was trained how to use the simulation software during the intervention. The intervention is the simulation-based teaching depicted by this schematic model.

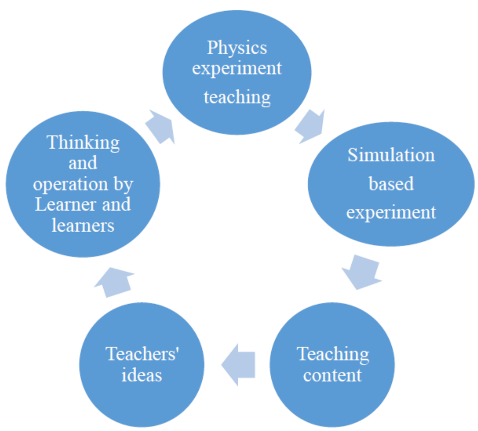

FIGURE 2: Schematic depiction of simulation-based teaching method for experimental task.

Two intact classroom sections of grade nine were selected as experimental and control group where the condition of homogeneity was fairly assumed to be fulfilled. The same teacher was in charge of teaching the two sections. In the absence of physics laboratory only computer simulations were used.

The quasi-experimental nonequivalent control group design was used. The intervention was applied in tutorial and laboratory classes. There were four tutorial sessions (on the set of four problem worksheets) and three laboratory sessions (on three simulation experiments) where new instruction method was implemented in teaching experimental group and the usual teacher-centered teaching method was implemented in teaching the control group on the chapter about temperature and heat for ninth grade.

C. Sampling procedure

The experimental group was sampled to include N = 49 number of students out of which M (male) = 32 and F(female) = 17 and the control group was sampled to include N = 50 number of students out of which M (male) = 33 and F (female) = 17. It should be noted that all the available sections of ninth grade were sampled. The same teacher taught both groups on the chapter about temperature and heat. The ninth-grade physics text book includes the concept of temperature and heat in a chapter. The chapter mainly focuses on measuring temperature and heat as physical quantities, thermal expansion, heat exchange, and change of phase.

Basic models in temperature and heat which are found in ninth grade text book.

TABLE I. Basic models of temperature and heat.

No	Conceptual models	Mathematical models
1.	Heat and temperature are manifestations of molecular motion and configuration.	$Q = mc\Delta T$
2.	Thermal expansion occurs as a result of temperature raise where the particles of the substance gains kinetic energy and so move more rapidly.	$Q = \Sigma E_k + \Sigma U$
3.	Heat transfer depends on thermal conductivity of a solid, mass transport in a gas and liquid, and emission and absorption of radiant energy.	Heat current = $J_q(x,y,z)$ α – ($\Delta T/\Delta x$, $\Delta T/\Delta y$, $\Delta T/\Delta z$) α is proportionality constant
4.	The more we heat up a substance the bonds between the particles in the substance are broken and the potential energy of the particles increases, the substance changes phase (state).	Latent heat of fusion = $Q = mL_f$ Latent heat of vaporization = $Q = mL_v$

D. Data collection procedure. Achievement test

The achievement test includes 25 items of selection type (matching, multiple choice and true/false) and explanation type (free response). The reliability of the test was established with the calculated value of Cronbach's Alpha (α = .616). The two physics teachers rated whether each item is essential based on their response the calculated content validity ratio is CVR = .65. Questionnaire. The problem-solving strategy scale (PSSS) and the experimentation skill questionnaire were used. Interview Open type questions were used.

III. THE RESEARCH RESULTS

The pretest means score and the corresponding standard deviation for both experimental and control groups given in Table II, 11.2 (2.3) and 10.6 (2.5), respectively also confirms their similarity. Besides, the Levene's independent t-test for equality of variance for distribution of students both in treatment and control group ($p > .05$) at t-value 1.33 and two tailed p-value .2. Table III, also supported the initial assumption that there was no significant difference between the two groups at the pretest (p > .05) at α = 95%.

TABLE II. The pretest and posttest performance of students in the achievement test.

Data type	Experimental group						Control group					
	Pretest			Posttest			Pretest			Posttest		
	F	M	N	F	M	N	F	M	N	F	M	N
# of students	17	30	47	17	32	49	14	30	44	17	33	50
Mean	10.3	11.8	11.2	13.3	15.3	14.6	10.9	10.4	10.6	12.6	12.8	12.7
SD	2.3	2.2	2.3	2.7	2.8	2.9	2	2.8	2.5	1.9	3.3	2.9

TABLE III: Independent sample t-test of pretest mean scores.

Test	Levene's Test for Equality of Variance		t	df	Sig.(2-tailed)
	F	Sig.			
Pretest	.212	.65	1.3	43	.2

TABLE IV. Independent t-test of posttest mean scores.

Test	Levene's Test for Equality of Variance		T	df	Sig.(2-tailed)
	F	Sig.			
Posttest	.48	.49	3.3	48	.001

The result given in Table IV revealed that as it was predicted in the first research hypothesis, there was significance difference in scores for EG, M = 14.6, SD = 2.9 and CG, M = 12.7, SD = 2.9; t = 3.3, p = .001 < .05 (two-tailed).

TABLE V: Paired samples t-test of mean scores for males and females of the experimental group.

Gender group	Mean Difference	SD	t	df	Sig. (2-tailed)
Female Pretest – Posttest	2.97	.9	.32	16	.005
Male Pretest – Posttest	3.4	3.7	5.1	29	.000

There were no significant enhanced change in achievement test scores for female students, whereas there were enhanced change in achievement test scores of male students in the experimental group. The mean score differences and the corresponding standard deviation 2.97 (.9) at t-value .32 the p-value is .005 and 3.4 (3.7) at t-value 5.1 the p-value is .000 for female and male students of the experimental group, respectively also suggest that there was significant improvement for male students of the experimental group compare to the female counterparts. This study that confirmed gender differences in the degree of academic achievement in temperature and heat.

TABLE VI. Correlation coefficients between the posttest scores and formative assessment scores of problem solving and experimental activities.

	R	p-value
Correlations between posttest and problem solving activities	.322	.024
Correlations between posttest and experimentation activities	-.086	.604

The problem solving activities were frequently set in tutorial classes and as predicted there was significant correlation between scores of problem activities and posttest scores, r = .322 and p-value .024 < .005. The problem solving activities were always subjected to a timely formative assessment and feedback. The students were not experienced enough during the implementation of experimentation activities and experimentation activities were not done exhaustively as a result no significant correlation was found between scores of experimentation activities and posttest scores.

The overall impact of the intervention as reported by both the students and the teacher as revealed by the questionnaires, interview, and checklist was positive since it was helpful for students learning.

V. CONCLUSION

The new teaching method named as visualization assisted teaching method compared to the traditional lecture method can bring better scores in achievement test when it is applied in temperature and heat for grade nine. The correlation analysis revealed that visualization assisted teaching method has advantage in bringing better problem solving performance but simulation-based teaching method didn't bring better experimentation performance due to experimentation activities limitation.

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