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Discovering Knowledge in Mathematics and Dynamic Modeling

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Abstract: Establishing and improving the quality and standards in mathematics education, the learning process have to be designed according to mathematics contend knowledge, pedagogic content knowledge and technologic content knowledge and especially Inquiry Based Learning and Problem Solving Model (IBLPS) (Ardahan H. & veErsoy Y., 2001). IBLPS model consist of five critical steps involving construction of a suitable model for a problem, data collection, prediction of relations among the data, generalization and evaluation (Ardahan H., 2008). Dynamic modeling helps students to create, exploit and fix cross-curricular links and to lead them through the whole process of discovering and learning about laws and nature (Valek J. & Sladek P., 2011). Mathematical modeling has very important roles on critical thinking, reasoning, raising awareness about mathematical order (NCTM, 2000).

If we describe the learning concept as “learning is a mental transformation of a suitable model of the problem to the dual coded mental image” then we can see the importance and the role of the dynamic mathematical modeling and Smart Learning Objects describing a mathematical concept in learning process.

This research has an experimental study design. It aims to show how IBLPS modeling affects the mathematical learning process. Data is collected by the five-point Likert’s type Dynamic Modeling Activity Scale (DMAS) and analyzed by t-tests. Moreover, in order to figure out the validity of the test results, qualitative evaluations are used.

In accordance with this purpose, the attainments about the IBLPS model throughout the learning process have been constituted for more than fifteen years are going to be discussed among the education community.

Also, this study involves the innovative design of learning process and our original lesson activities. The research also puts forward how thinking and learning mathematics concepts need to be modeled according to the IBLPS approach.

The study also focuses on the prospective teachers’ perception on quality in learning and teaching mathematics and the effects of dynamic modeling on the learning process.

Designing the learning process IBLPS model and using dynamic modeling aims active participation of students obtaining mathematical thinking, discovering knowledge, and gaining meaningful and permanent learning skills. The research is expected to be a model for young researchers.

Key words: dynamic modeling, Inquiry Based Learning and Problem Solving Model, lesson activities

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1. Introduction

Mathematical modeling has very important roles on critical thinking, reasoning, realizing of mathematical order, reinforcement of making personal estimates and managing the meaningful learning process. Especially, National Council of Teachers of Mathematics (NCTM) considers that the presenting of the information in different ways is essential to understand the mathematical thinking (NCTM, 2000). Also, NCTM states that prospective teachers use varied representations of mathematical ideas to support and deepen students' mathematical understanding (NCTM, 2003).

Mathematical modeling activities move beyond traditional problem solving to encourage children to develop and explore significant, real world mathematical ideas (Fox J., 2006). Also, mathematical modeling is also a process trying to find a solution for daily life problems, and representing the process with mathematical terms (Cheng A. K., 2001). Modeling activities have an important role in mathematics education as they are extremely valuable for mathematical thinking and learning. In recent years, the importance of modeling has been emphasized by many countries' mathematic programs. On the mathematic programs prepared recently for both primary and secondary schools in our country, the mathematical modeling is emphasized. However, there aren't sufficient modeling application in mathematics curriculum (MEB-TTKB, 2005). Briefly, Mathematical modeling is the most supporting activity for creative developments (Galbraith P., 1995).

If we describe the learning concept as "learning is a mental transformation of a suitable model of the problem to the dual coded mental image" then we can see the importance and the role of the mathematical modeling and dynamic modeling and Smart learning Objects describing a mathematical concept in learning process.

Dynamic modeling provides continuous evaluation of what we have constructed throughout the learning process (Systems-thinking.org, 2010).

Stratford explains the necessary cognitive strategies for students in order to form a dynamic model in for any fact or problem:

- *Analyzing:* It is a way of dissection of a problem or a fact and definitions of important components in other words whether the components are efficient on the behaviors of the model or not. This is the stage of determining which of the problematic components should take place in the model and commenting on the model's behavior.
- *Relational reasoning:* This section consists of the actions and conditions which based on the prediction of reasoning the relationships among the certain components, between the forms and objects and reasoning about the model's behaviors.
- *Synthesizing*: Considering the content of the model and taking the behavior as a whole, this part is formed by the event that aims to gather the ideas that have never been associated before.
- *Testing and correcting*: Determining whether the model serves the purpose properly or not. If there is a problem, the reason will be found and corrected in this part.
- *Explanation:* Here, the aim is to explain in a reasonable way to find out how the relationship occurs in a model and why a case changes in another situation. In other words, it explains how and why the cases of a model occur in a logical way (Stratford S. J., Krajcik J. & Soloway E., 1998).

The well-organized learning environment is necessary for students to carry out these stages. The more comprehensible modeling is done, the more evolution is obtained on the high cognitive abilities (Butler D. L. & Winne P. H., 1995).

The term, inquiry learning, refers to a systematic (hierarchy) composed of critical steps guiding the discovery of the new information, thinking mathematics, reasoning ideas, problem solving and learning. Programmed learning is a learning process design based on technology that the most effective things are emotional, spiritual, physical and intellectual (holistic) and exploring and solving problem (heuristic). IBLPS model directly supports dual coding theory of Paivio, Multimedia learning Theory of Mayer, ARCS motivation theory of Keller and the learning strategies of constructivism.

Inquiry Based Learning Model consists of five critical sequenced steps as follows:

(1) Construct a suitable model for a problem,

(2) Collect data from the model,

(3) Predict relations among the data,

(4) Generalize the relations and discover knowledge,

(5) Evaluate the process.

You can see the IBLPS model at the Figure 1 (Ardahan H., 2011).

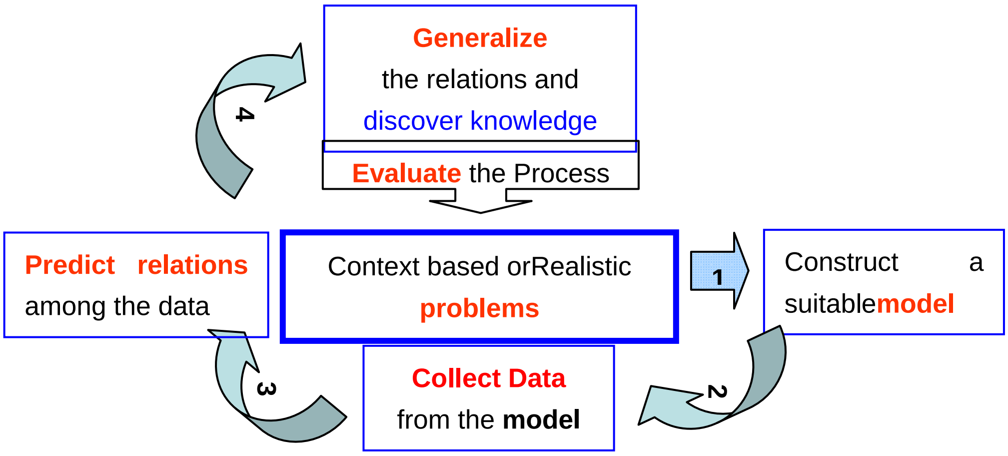

Figure 1 Inquiry Based Learning and Problem Solving Model

The reliability of the information emitted from the Internet is gradually decreasing (Sundar S. Shyam, 2008). Computer software and materials based on learning by repeating aren't suitable for active learning. The models based on inquiry learning offers much more reliable source of information. Data sources based on the exercises of Learning by repetition doesn't encourage the improvement of creativeness and provide discovery (Ginn W. Y., 2010).

So designing the teaching process and the classroom activities, taking into account of IBLPS and dynamic modeling, makes the students responsible of their own learning and giving encouragement to students by proving conditions aiming to discover the data. Physical conditions, technology and multimedia raise the quality of learning.

Learning environment with physical conditions, technology and multimedia raise the quality of learning. Literature data and the exiting education practices argue that producing a good dynamic modeling is impossible without improving cognitive critical thinking ability, self-confidence and regulation ability and competence. Our education practice and opinions revealed that an interactive dynamic modeling is impossible without improving critical thinking and regulation abilities and self-confidence and competence on learning process.

2. Research Problem

The research has emerged in order to find answers to the following problems.

(1) What are the effects of the dynamic modeling in accordance with IBLPS model on the learning process?

(2) How can the learning process be designed by IBLPS model?

These educational problems form the basis of this research.

3. Research Method

The present study was conducted based on an experimental study design using a pretest-posttest group and a control group. This study design was preferred as if provides a reliable approach to research cause and effect relation. The participants of this study were prospective mathematics teachers randomly selected from Necmettin Erbakan University, Faculty of Education, and Department of Mathematics in 2013.

During the study the experimental group used dynamic instructional materials designed by the author as a teaching tool and the control group received instruction by means of traditional teaching. You can see a few instructional materials' cover to get an opinion about the teaching tools and learning environments.

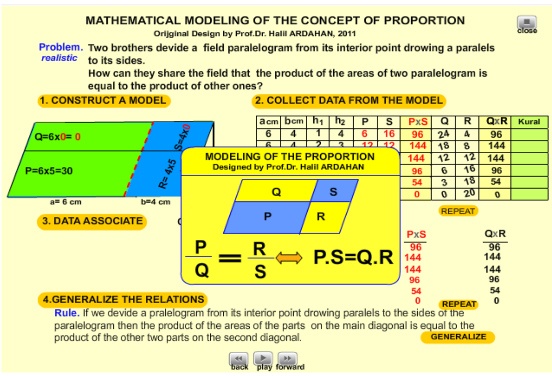

Figure 2 Teaching Proportion tool

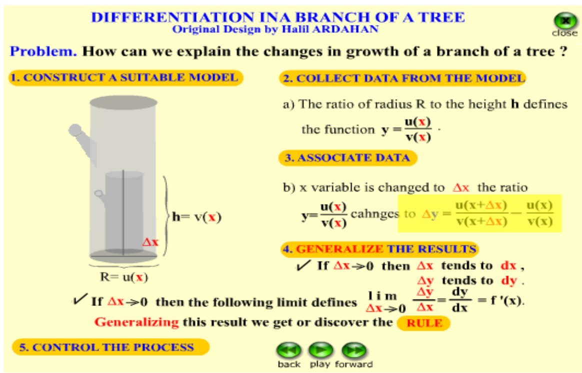

Figure 3 Teaching Differentiation in a Branch

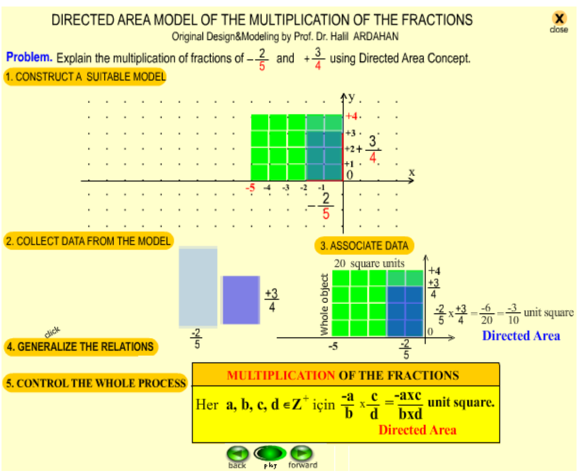

Figure 4 Teaching of Mult. of Fractions Tool

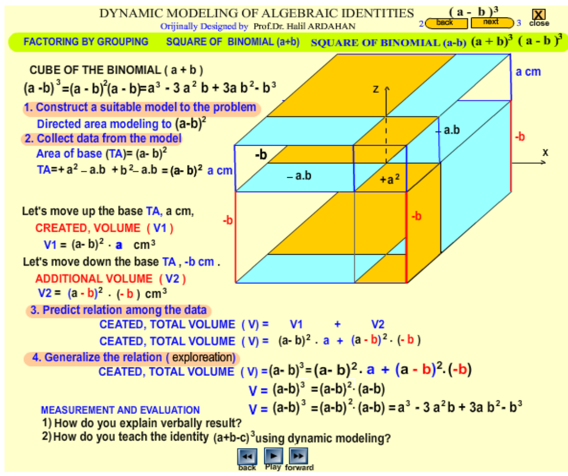

Figure 5 Teaching of (a-b)^3 tool

In order to measure the effects of IBLPS which is based on dynamic modeling, to the learning process, Dynamic Modeling Activity Scale (DMAS) is improved and applied to 128 prospective teachers. DMAS has subscales related to motivation, mathematical thinking and expression, participation, active learning, predicting relations and discovering new knowledge. DMAS used as the data collecting tool of the study which is Likert type five-point scale encompasses ten items ranging from “never = 1” to “always = 5”, The validity and reliability of scale identified by a pilot implementation in 2011 (Ardahan H., 2011).

4. Data Analysis

The reliability coefficient Cronbach Alfa (R) of the scale is found 0,865 and Barlett’s sphericity $p < 0.05$ for the eligibility and factor analysis of data. Also, KMO (Kaiser-Mayer-Olkin) index is found 0.867 for the scale is quite sufficient for size and factor analysis.

You can see some statistical results concerned with the scale DMAS in Table 1.

Table 1 Normality of Data Set and homogeneity of Variances

	Pre-test	Post-test
N	128	128
Kolmogorov- Smirnov Z	1.237	1.314
p	0.095	0.063
Levene’ s Statistics	1.614	1.162
p	0.073	0.319

Kolmogorov and Smirnov test results showed that data set has normal distribution and homogeneity of variances was determined by Levene’s test.

Since the obtained data has normal distribution, the scores of means of the groups were compared with parametric tests and Paired Sample T-tests. SPSS 16.0 statistical package is used for data analysis.

5. Findings and Comments

Is there significant difference between pre and posttest scores of experimental and control groups?

We can calculate the mean scores of the pre and post-test data using Paired Sample Statistics as follows:

Table 2 Paired Sample Statistics

Samples	N	Mean ($\overline{X}$)	ss	sd	t	p
Pre-test Scores	128	3.9210	.55075	127	8.260	.000
Post-test Scores	128	4.4297	.41041			

**$p < 0.05$

As can be seen in Table 2, there is a statically significant difference at about $p = 0.05$ level between the pretest and post test scores. As can be clearly seen that when the average of the pre test scores (3.9210) and the average of the post test scores (4.4297) are taken into account, the difference is meaningful in favor of the post test scores. It is important to predict the reasons and factors explaining this difference. For his purpose it was calculated the correlations between main difference and pre-test and post-test difference in each item.

In the following Table 3, you can see the significant linear correlations and their level of effect on the main difference.

Table 3 Paired Sample Correlations

Main Difference	Posttest-pre-test difference in item 7	Posttest-pre-test difference in item 8	Posttest-pre-test difference in item 9	Posttest-pre-test difference in item 4	Posttest-pre-test difference in item 1
Pearson Correlation	.773	.748	.696	.678	.667
p	.000	.000	.000	.000	.000
N	128	128	128	128	128

5.1 Findings

The findings acquired from this research are presented below.

(1) In the first level, teaching the mathematics concepts and process with the dynamic designed IBLPS modal provides meaningful and permanent learning compared with the traditional teaching (Ardahan H., 2011).

(2) In the second level, dynamic designed instructional models help student to describe and dual coding of mathematics knowledge easier.

(3) In the third level, students creates more reliable and anchored knowledge using IBLPS designed dynamic models.

(4) In the fourth level, IBLPS designed dynamic models provide students to discover relations and new knowledge.

(5) In the fifth level, IBLPS designed dynamic models with real life context provide students more qualified and exploratory learning.

5.2 Suggestions

The reformed suggestions according to the findings obtained from the research are as below.

- IBLPS designed dynamic models ought to be used in teaching and learning process to create active learning.
- Prospective mathematics teachers should have competences on dynamic mathematical modeling.
- Mathematics and Teacher Training Programs should be revised and renewed by the latest improvements in ICT.

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