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A teaching model impact of learning outcomes for mathematical content in functions

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Abstract

This study aims at measuring the effectiveness of a teaching model based on learning outcomes according to the system approach in helping students acquire the standards for mathematical content in functions.The study was applied to two hundred students of eight sections which were randomly divided into two groups: control and experimental. The first instrument was a pre-test designed to determine the comparability of the two groups' performance in the prerequisites. The second was a post-test, investigating the effectiveness of the model after treatment. It was discovered that the model significantly improved the students' performance in interpreting functions, building functions, and polynomial models.

Keywords: System approach, Learning outcomes, Mathematical content standard, National Council of the Teachers of Mathematics (NCTM).

Un impacto del modelo de enseñanza de los resultados de aprendizaje para contenido matemático en funciones

Resumen

Este estudio tiene como objetivo medir la efectividad de un modelo de enseñanza basado en los resultados del aprendizaje de acuerdo con el enfoque del sistema para ayudar a los estudiantes a adquirir los estándares para el contenido matemático en las funciones. El estudio se aplicó a doscientos estudiantes de ocho secciones que se dividieron aleatoriamente en dos grupos: control y experimental. El

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primer instrumento fue una prueba previa diseñada para determinar la comparabilidad del rendimiento de los dos grupos en los requisitos previos. El segundo fue una prueba posterior, que investigó la efectividad del modelo después del tratamiento. Se descubrió que el modelo mejoró significativamente el rendimiento de los estudiantes en la interpretación de funciones, funciones de construcción y modelos polinomiales.

Palabras clave: Enfoque Del sistema, Resultados de aprendizaje, Estándar de contenido matemático, Consejo Nacional de Maestros de Matemáticas (NCTM).

1. INTRODUCTION

As the focus of this study, mathematics is an integral part of our daily lives which has become increasingly important on the highest levels of pedagogical concerns (KILIC& ASKIN, 2013). Most students, however, view mathematics as difficult, inapplicable, and demanding of a special set of capabilities that most students do not have (KILIC, CENE, AND DEMIT, 2012). This is further complicated by the fact that students have their own learning patterns and different ways of thinking and processing when it comes to dealing with mathematical information. As a result of these idiosyncrasies, Veloo & Ali propose that the students be the center of the learning process whereby their inputs (capabilities and inclinations) and their learning outcomes are carefully determined. Then, through processing the inputs, the learning outcomes are achieved (VELOO and ALI, 2014).

Taken into consideration this peculiarity of learning mathematics, there has been a growing tendency to focus on learning outcomes, which were defined by Guderva & Trajkaval as those written sentences that define what a successful learner is expected to achieve by the end of a course, a unit, or an educational stage (GUDERVA and TRAJKAVAL, 2012). It has also been established that a teaching model based on leaning outcomes, as outputs, foregrounds the competence of the student as the center of the learning process. Such a model is more modern and comprehensive than the traditional model which prioritizes inputs such as content and teaching hours (KENNEDY, 2007; PSIFIDOU, 2009). Therefore, designing courses based on learning outcomes has become an increasing international practice (CEDEFOP, 2008; COSLING and MOON, 2001). For example, all level-three courses in European higher education institutions are required to be built around the concept of learning outcomes and designed in a way that materializes this concept (ADAM, 2004). What corroborates the importance of basing teaching mathematics on learning outcomes is the fact that the National Council of the Teachers of Mathematics has formed the general guidelines and standards for learning outcomes in all educational stages and in all areas of mathematics (NCTM, 2000).

Based on the above, it is necessary to design a teaching model that perceives the student as the center of the learning process and utilizes the input and processes to achieve the learning outcomes. Such a model has to comprise the input, processes, and learning outcomes in a way that reflects the interrelatedness between them while being flexible enough to enable potential adjustments of any of these elements based on feedback and observation. The system approach, therefore, is a successful candidate that meets such requirements. The system approach is defined by Macy as an analytical method which organizes parts in a system whereby these parts consolidate, each according to its function, to achieve the goals set for a certain task (MACY, 2005).

The teaching model proposed here was based on the system approach of the learning outcomes according to the standards for the international mathematical content in functions as defined by the National Council of the Teachers of Mathematics (NCTM) and aimed at the students of the preparatory stage of university. This model was inspired by the fact that the students of the preparatory program at the University of Hail, according to the program's statistical records, have always demonstrated difficulty in comprehending the course and scored lowest in its "polynomial functions" unit.

Research Questions

This study sets out to answer a major question, that is, "what is the impact of using a teaching model of the learning outcomes according to the system approach on students' acquisition of the standards for mathematical content in functions?" To answer this question, a series of related questions were branched out as the following:

1- Are there any statistically significant differences between the marks average of the students in the control group and that of the students in the experimental group in the course outcome statements test (COST)?

2-Are there any statistically significant differences between the marks average of the students in the control group and that of the students in the experimental group within the standard of interpreting functions (F-IF: Interpreting Functions)?

3-Are there any statistically significant differences between the marks average of the students in the control group and that of the students in the experimental group within the standard of building functions (F-BF: Building Functions)?

4-Are there any statistically significant differences between the marks average of the students in the control group and that of the students in the experimental group within the standard of linear, quadratic, and polynomial models (F-LE: Linear, Quadratic, and Polynomial Models)?

Limitations of the Study

One of the limitations of this study is being restricted to only one unit of the overall content (the College Algebra textbook) whereas ideally, the whole content should be designed based on the system approach model. Another potential limitation of this study is the element of the instructor. The results of this study might be affected by the differences between instructors. There is also the possibility that the instructors who agreed to be a part of this study and teach the experimental group using the system approach model have certain qualities, skills, and more flexibility than those instructors who taught the control group. Unfortunately, the element of the instructor's influence is unavoidable.

2. Learning Outcomes According to the System Approach (LOSA MODEL)

A theoretical teaching model was designed for learning outcomes according to the system approach which included the procedural processing (processes) required to handle the inputs to achieve the learning outcomes (outputs). The model is demonstrated in Figure 1. The model was refereed by a group of specialists in curriculum and teaching methods of mathematics and was modified based on their feedback. The electronic part of the model was designed on Blackboard and reviewed by a computer specialist and then evaluated by a specialist in mathematics curriculum and teaching methods to test its suitability for treatment in the classroom.

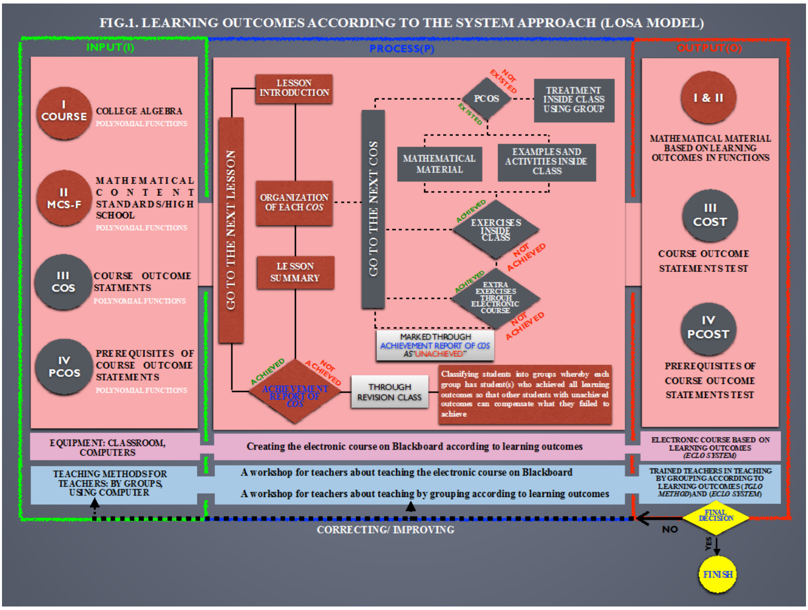

FIG.1. LEARNING OUTCOMES ACCORDING TO THE SYSTEM APPROACH (LOSA MODEL)

Mathematical Content Standard in Functions (MCS-F)

This framework includes the standards for mathematical content in functions at high school level as set by the NCTM; these standards are

- F-IF: Interpreting Functions

- F-BF: Building Functions

- F-LE: Linear, Quadratic, and Polynomial Modals

Using these standards, the learning outcomes and their prerequisites have been derived based on the content of the College Algebra course for the preparatory stage at university.

Course Outcomes Statements (COS) Vs. Their Prerequisite (PCOS)

The course outcome statements and their prerequisites have been shaped with the help of referees specialized in mathematics. These COS's and PCOS's were revised into their final form as in Table1.

Table1: The Relationship between (COS) and (PCOS)

MCS-F	COS: Course Outcome Statements	PCOS: Prerequisites of COS's
F-IF Interpreting Functions	• The ability to determine the slope of horizontal, vertical, and any line passing through two points • Defining X and Y intercepts for any line	• Understanding the concepts of: O, undefined • Determining a point that lies on any

	• Using the graph of any linear $x\ and\ y$ function to define the features intercepts as well as slope • Defining the basic features of the quadratic function: vertex, minimum-maximum value and equation of symmetry • Defining the basic features of polynomial functions • Determining the type of polynomial graph	given linear equation or on its graph • Solving any linear equation with one variable • Solving any quadratic equation $ax^2 + bx + c = 0$, where $a \neq 0$
F-BF Building Function	• The ability to construct the equation of the line under given conditions • The knowledge of the quadratic function forms: standard and shifted • The ability to reconstruct any quadratic functions from standard to shifted or vice versa • Using the graph of any quadratic functions to build the equation • Using the graph of any polynomial function to construct its equation	• Rewriting a given linear equation with more than one variable in terms of one of its variables • Writing X and Y-intercepts as an ordered pair • Understanding the relationship between parallel/perpendicular lines • Applying the completing square technique to the quadratic function • Defining increasing-decreasing intervals for any polynomial graphs • Defining the zeros of any polynomial equations written in factored form • Constructing the poly with integer coefficient from real zeros degree
F-LE: Linear, Quadratic, and Polynomial Models	• The ability to design the graph of linear model: constant, vertical, and oblique • The ability to design the graph of quadratic model • The ability to design the graph of	• Using the table to graph linear equation with two variables • Using the table to sketch the graph of any non-linear equation

	the polynomial model: $f(x) = ax^n + bx^{n-1} + \cdots + cx^0$	with two variables • Defining the degree and substitute for any factorable polynomial • Solving any factorable polynomial equation

2. METHODOLOGY

The targeted population of this study is all the Science Track students at the Preparatory Year College of the University of Hail in Saudi Arabia, of the 2016 / 2017 class. These students, numbered two thousand males and females, were distributed into eight sections studying the College Algebra course. Out of the overall number of sections, 10% were randomly chosen as a stratified random sample and then randomly divided into two groups: control and experimental. Table 2 explains the structure of the two groups in terms of the number and gender of students per section.

Table.2. Distribution of sections in the experimental and control groups according to gender

Gender	Groups		
	Experimental	Control	Total
Male	3	3	6
Female	1	1	2
Total	4	4	8

Note: The number of students per section is 25

The research was conducted in a pre-test/post-test control-grouped experimental pattern. In this study, two measuring instruments were developed and administered:

Prerequisites of Course Outcome Statements Test (PCOST)

A test of the prerequisites of course outcome statements was developed to evaluate the extent to which the study groups have mastered the prerequisites and to ensure the comparability between the control and experimental groups in these prerequisites. This test was administered before applying the system approach to eliminate any post-effects that can be attributed to how well the students of each group have already mastered the prerequisites. The test consisted of seventeen multiple-choice questions classified within the standards for mathematical content in functions. The instrument's validity was tested through refereeing the content by mathematicians, in addition to using the Bivariate Correlation after applying the instrument to a pilot sample. The results of the pilot sample revealed a significant connection between the test and the standards for mathematical content, which supports the validity of the instrument as shown in Table 3. The reliability of the instrument also had a Cronbach's Alpha Coefficient of (0.803).

Course Outcome Statements Test (COST)

The course outcome statements test was developed to measure the impact of using the learning outcomes system approach on the overall students' performance and on each of the standards for mathematical content. The test consisted of fourteen multiple choice questions classified according to the standards for mathematical content in functions (M CS-F). The content of the test was refereed by mathematicians and then given to the pilot sample to ensure its validity and reliability. The test featured a Cronbach's Correlation Coefficient at (0.70) whereas its validity was measured using the Bivariate Correlation which indicated high validity as shown in Table 3 below.

Table 3: Correlation between MCS-F and the overall score in PCOST and COST

Mathematical Content Standard in Functions (MCS-F)	Prerequisites of Course Outcome Statements Test (PCOST)		Course Outcome Statements Test (COST)	
	Pearson Correlation	Sig.(2-Tailed)	Pearson Correlation	Sig.(2-Tailed)
F-IF: interpreting functions	0.81**	0.000	0.89**	0.000
F-BF: building functions	0.92**	0.000	0.79**	0.000
F-LE: linear, quadratic, and polynomial models	0.76**	0.000	0.73**	0.000

** Correlation is significant at the 0.01 level (2-tailed)

The mathematical content of the College Algebra course was approved, and the study focused on the functions unit of the course as a result of the students' low performance in that unit according to the statistical records of the previous year. Then, a refereeing committee consisting of five faculty members (three specialized in algebra and two in mathematics curriculum and teaching methods) was formed to evaluate the research instruments. The standards for mathematical content in functions were shaped based on the specifications of the National Council of the Teachers of Mathematics and then used to design the learning outcomes expected of the functions unit of the College Algebra course. The prerequisites were also tied to the learning outcomes before evaluating the content by the refereeing committee whose feedback was utilized in making the necessary adjustments.

The content was reshaped based on the learning outcomes system approach (LOSA), Fig.1, and the electronic course according to learning outcomes (ECLO system) was created on Blackboard with the help of a computer specialist. The content and the ELCO system was then evaluated by a referring committee whose feedback was used to make the necessary adjustments. Next, a pilot sample of twenty male and female students was created to ascertain the validity and reliability of the pre-test and the post-test. After that, the study sample was chosen and randomly divided into control and experimental groups with instructors assigned to teach each group. The instructors of the experimental group were trained in using the teaching model and the ECLO system. The instructors then trained the students of the experimental group to use ECLO system.

The next stage was designing the pre-test (PCOST) which evaluated the prerequisites related to the learning outcomes. The pre-test's validity and reliability were verified through the pilot sample in order to ensure comparability between the study groups before the treatment of the model. The actual teaching using the LOSA model took one month before administering the post-test (COST). This test was also based on learning outcomes, and its validity and reliability were determined through the pilot sample. The test was then given to the study sample to measure the impact of using the LOSA model on the students' performance.

3. RESULTS AND DISCUSSION

The data was analyzed using frequency, percent, mean, standard deviation, and the T-test for independent samples. The results indicated the following:

The Results of the Prerequisites of Course Outcome Statements Test (PCOST)

The control and experimental groups were given the PCOST before the treatment of the model in order to determine their comparability. The analysis of the differences of the average scores of prerequisites of course outcome statements test (PCOST) found that there was no statistical difference at 0.05 level of significant (t=-0.053, sig=0.958) as detailed in Table 4.

Table 4: The results of the control-experimental groups in the prerequisites of course outcome statements test

Groups	N	Mean	SD	df	t	Significant (2-tailed)
Control	100	3.91	2.84	198	- 0.053	0.958
Experimental	00	3.93	.52			

After the treatment of the model, the study’s two groups were given a COST to measure the effect of using the (LOSA) model on their acquisition of the standards for mathematical content in functions. As illustrated in Table 5 later on, the analysis of the differences of the average scores of the course outcome statements test (COST) found that:

- There was a statistical difference in the overall score (MCS-F) at 0.05 level of significant (t = -5.77, sig = 0.000). The scores from the experiment (Mean = 8.01, SD = 3.04) was higher than the scores of the control (Mean = 5.53, SD = 3.04).

- There was a statistical difference in interpreting functions scores (F-IF) at 0.05 level of significant (t = -5.28, sig = 0.000). The scores from the experimental (Mean = 3.15, SD = 1.36) was higher than control scores (Mean = 2.12, SD = 1.40)

- There was a statistical difference in building functions scores (F-BF) at 0.05 level of significant (t = -3.98, sig = 0.000). The experimental scores (Mean = 2.62, SD = 1.38) was higher than control scores (Mean = 1.88, SD = 1.25)

- There was a statistical difference in linear, quadratic, and polynomial models scores (F-LE) at 0.05 level of significant (t = -4.31, sig = 0.000). The experiment scores (Mean = 2.24, SD = 1.17) was higher than control scores (Mean = 1.53, SD = 1.17).

Table 5: The results of the control-experimental groups in the Course Outcomes Statements Tests

The Group		Cost Scores MCS-F	F-IF Interpreting Functions Scores	F-BF Building Functions Scores	F-LE Linear, Quadratic, and Polynomial Models Scores
Experimental	N	100	100	100	100
	Mean	8.01	3.15	2.62	2.24
	SD	3.04	1.36	1.38	1.17
Control	N	100	100	100	100
	Mean	5.53	2.12	1.88	1.53
	SD	3.04	1.40	1.25	1.17
T-Test	t	-5.77	-5.28	-3.98	-4.31
	sig	0.000	0.000	0.000	0.000

4. CONCLUSION

Based on the results yielded by this study, it can be deduced that using the learning outcomes according to the system approach (LOSA) model has a positive impact on the students' acquisition and performance in interpreting functions; building functions; and polynomial models, especially linear and quadratic. It is also noted that the LOSA model was most effective in helping the students acquire the skill of interpreting functions (F-IF).

RECOMMENDATIONS

Through this study, the LOSA model has proved to be effective in helping the students acquire the learning outcomes of the most difficult unit of the College Algebra course. Therefore, it is recommended that the course be restructured according to the LOSA model. Taking it further, there seems to be a need for a study that undertakes the formation of measurable standards for failure and passing in the course. Such a study would have to be based on the LOSA model which has proved effective in enhancing academic performance. In addition, it is advised to establish a mechanism for the classification of failing and passing students based on achieved and unachieved learning outcomes whereby the passing students are distributed into sections of the next course based on these outcomes. Finally, the model can be applied in other courses and educational stages to measure its effectiveness there.

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REFERENCES

ADAM, S. 2004. **Using learning outcomes: A consideration of the nature, role, Application and in dictations for European education of employing learning a team of the local, nautical and international levels.** Report on United Kingdom bologna seminar, July 2004, Herriot-watt University.

CEDEFO. P. 2008. **The shift to learning outcomes: conceptual, political and practical developments in Europe Executive Summary**, Luxembourg.

COSLING, D. AND MOON, J. 2001 **How to use learning outcomes and assessment criteria**. London, SEEC Office.

GUDERA, L. DIMOVA, V. DASKALOVSKA, N. TRAJKOVA, F. 2012. "Designing descriptors of learning outcomes for higher education qualification social and behavioral sciences", 2(46), 1306-1311. V.

KENNEDY, D. 2007. **Writing and using learning outcomes**. Cork: Quality promotion Unit, UCC.

KILIC, S. ASKIN, O. 2013. "Parental influence on students' mathematics achievement: The comparative study of Turkey and best performer countries in Tim SS 2011". **Social and behavioral sciences**, 4(106), 2000-2007.

KILIC, S. CENE, E. & DEMIT, I. 2012. "Comparison of learning strategies for mathematics Achievement in Turkey with Eight Countries Educations sciences". **Theory & Practice**, 12.4, 2594-2598.

MACY, MARISQ Q. 2005. "The development systems approach to early intervention". **Topics in early childhood special education, summer**, 25(2)119-121.

PSIFIDOU. 2009. **Innovation in school curriculum: the shift to learning out comes social and behavioral sciences**. 2(1), 2436-2440.

VELOO, A. ALI, R. 2014. "Affective determinants of additional mathematics achievement in Malaysia technical secondary school". **social and behavioral** (science, 3(112), 613-620.

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