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Impact of two different infographics types "interactive-static" on developing mathematical concepts among female students at second grade intermediate in the Kingdom of Saudi Arabia

Mohamed Shaltout[1] and Hania Fatani[2]*

[1]Department of Education Technology, Arab East College For Graduate Studies, Saudi Arabia.
[2]Supervisor of Learning Resources, Yanbu City, Ministry of Saudi Education, Saudi Arabia.

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ABSTRACT

This study was aimed at identifying the impact of two infographics types (interactive and static), on developing mathematical concepts among female students at second grade intermediate in the Kingdom of Saudi Arabia. A quasi-experimental approach was adopted; the population of the study consisted of 82 female students. The students were divided into three groups: An experimental group studied by using animated infographics based on, 'technology helps easy and practical accessible curriculum teaching (THEPACT) strategy, an experimental group studied by using static infographics based on THEPACT strategy, and a control group studied by using traditional method. Real numbers and Pythagoras theorem were reformulated by using infographics, an achievement test of mathematical concepts was also prepared, hypotheses were formulated and tested. The data obtained were analyzed using mean, standard deviation and one way analysis of variance at p≤0.05. The results of post application of the achievement obtained reveal a statically significant difference (p≤0.05) between the mean scores of control group and the experimental groups. The difference is in favor of the experimental groups. The results obtained also reveal statically significant differences between mean scores of the two experimental groups on some concepts, the differences were in favor of the static infographics based on THEPACT strategy.

INTRODUCTION

Learning concepts represents the cornerstone to learning mathematics and it is considered as a common goal in every stage of education. Although it is considered difficult for most students, educators still pay great attention to learning concepts. The difficulty can be attributed to the abstract nature of mathematics and the hierarchical system of developing concepts in learners' minds.

One of the most challenging hurdles in learning concepts comes from having teachers adopt a coaching approach. Teachers tend to involve students in learning by heart rather than involving them in learning and assimilating concepts (Rashed and Kashan, 2009). New strategies have been developed to overcome these hurdles. One of these strategies is. 'Technology Helps Easy and Practical Accessible Curriculum Teaching" or briefly defined as THEPACT. This strategy was developed by the education specialist, Phyl Macomber. She advocated using THEPACT as a 4-step roadmap for teaching anything. Macomber (2016) showed these steps as follows: Learn

*Corresponding author. E-mail: Taimaa@yahoo.com.

about, read about, write about and talk about. Educators need to do these steps in that order. Based on the longstanding research of how the brain works, it was found that teaching and understanding of a concept before testing it, helps students succeed.

Macomber and Quinn (2017) after their pursuit to train thousands of teachers to apply that strategy, stated that they had a significant success using the research-based methodology of THEPACT framework to directly teach students of all abilities, the fundamental knowledge of executive functioning skills and increase their understanding of the tools they put into play to assist them in the classroom. With regard to learning mathematics, it is observed that this strategy depends on employing mathematical communication skills. Hashash (2004) referred to these skills as an integral part in learning mathematics. This is associated with prompting students and encouraging them, by their teachers, to express their ideas and solutions in a clear and consistent manner.

Infographics emerged as an innovative way to simplify data and information. Infographics may be defined as visualization of information or ideas in order to communicate complex information to the public in a way that enable them to understand and assimilate this information quickly and easily. The adopted way in showing infographics helps more people to catch more information at a glance, without reading extended paragraphs (Shaltout, 2005).

Hassouna (2014) showed that infographics are designed in two ways: Static or interactive. The static infographics do not require any interaction from the users, meanwhile animated infographics depend on animation, and it catches viewers' attention with more spectacular and eye-catching visuals. Infographics help to inspire the designers on their quest to create innovative content that not only inspires and educates the viewers but also moves them to a specific action. Consequently, infographics can play an important role in delivering information and curricula content for students more effectively.

Mansour (2015) mentioned the fact that about 90% of information transmitted to the brain is visual, the brain processes images 60,000 times faster than it does text; and 50% of the brain power is directly or indirectly directed towards the visual effects, which confirms that the processing of visual information is less complex than processing of raw texts. This simply means that the brain craves for infographics. It is concluded that using infographics leads to clearer understanding of abstract concepts through drawings, timelines, flowcharts and varied array of different representations.

Many studies have shown the effectiveness of using infographics in teaching and learning, Mansour (2015) showed the positive effect of using infographics in developing productive habits of mind. Abo Osba (2015) referred to the effectiveness of using infographics in developing academic achievement. Kennedy et al. (2014) showed that infographics ease the process of analyzing qualitative data and interpretation of results for statistical problems.

As mentioned above, there is the need to employ new strategies and innovative technologies to teach mathematics concepts. In the kingdom of Saudi Arabia, students have a low level of academic achievement in understanding concepts. Alharby (2007) and Kashan et al. (2013) mentioned this issue. Alqahtani (2013), AlMughani (2015) and Almuhammdi (2013) stated that this issue comes from adopting traditional methods in teaching concepts. Based on the foregoing conclusion, this study was aimed at answering the following research questions:

- What is the impact of interactive infographics based on THEPACT on developing mathematics concepts among female students at the second grade intermediate?
- What is the impact of constant infographics based on THEPACT on developing mathematics concepts among female students at the second grade intermediate?
- What is the difference between two infographics types "constant and static" based on THEPACT on developing mathematics concepts among female students at the second grade intermediate?

The following study hypotheses were tested at $p \leq 0.05$ level of significance:

i. There is no significant difference in academic achievement mean score on mathematical concepts test between interactive infographics based on THEPACT and the control group;
ii. There is no significant difference in academic achievement mean score on mathematical concepts test between static infographics based on THEPACT and the control group;
iii. There is no significant difference in academic achievement mean score on mathematical concepts test between interactive infographics and static infographics.

MATERIALS AND METHODS

To answer the research questions, a mathematical concept test and two types of infographics (interactive and static) were developed as follows:

The mathematical concepts test

The test covered the 'real number and Pythagoras

theorem' unit. It consisted of 16 items on its initial form and was designed according to Frayer Model. The scientific and linguistic formula of the items were compiled. To achieve content validity and reliability of the test, assessment and measurement, mathematics methodology experts were consulted.

A pilot study was carried out to check the internal consistency and reliability of the test. A Pearson correlation coefficient and alpha-cronbach coefficient was calculated. According to this analysis four items were omitted, the statistical analysis for the results of the pilot study showed that each item is highly correlated with the overall test degree, alpha-cronbach coefficient was 0.89. These results showed high degree of internal consistency and reliability for the test, the final form of the test consisted of 12 items.

The infographics

The infographics were developed according to Shaltout's (2015) model. It contained five steps as follow:

- Study and analysis to analyze learners characteristics and the scientific content;
- Design step, in which the educational goals were determined, lines, diagrams and other representation were designed;
- Production step involved producing the initial model for infographics, Adobe Illustrator CC was used to design static infographics, Adobe Animate CC 2017 was used to design animated infographics. In this stage the following points were checked: the representation of entire scientific content, logical sequence of information and linguistic integrity;
- Evaluation step involves administrating the infographics by a group of expert arbitrators; and
- Finally publishing and application step in which the designed infographics were administrated to the sample of the research.

The study was designed as a quasi-experimental study. To reveal the impact of the different infographics design (static and animated), there was two experimental groups, the first group was studied by using animated infographics based on THEPACT strategy; the second group was studied by using static infographics based on THEPACT strategy; there was also a control group. The population of the study consisted of 82 female students at the second grade intermediate in city of Yanbu. They were divided as follow: 28 female student in the first experimental group, 27 female student in the second experimental group, and 27 in the control group.

Statistical analysis

The data was analyzed using mean, standard deviation and one way analysis of variance (ANOVA) to compare means between the three groups of the study.

RESULTS

Scores of the animated infographics based on THEPACT strategy

According to the results presented in Table 1, it can be said that there is differences between mean scores on mathematical concepts test between the animated infographics experimental group and the control group. To test these differences, one way ANOVA was performed at $p<0.05$ (Table 2). It was observed that the differences are in favor of the animated infographics experimental group. It can be said that there is a significant difference ($p<0.05$) in academic achievement mean score on mathematical concepts test between the interactive infographics based on THEPACT and the control groups.

Scores of the static infographics based on THEPACT strategy

From Table 3, it can be said that there is differences between mean scores on mathematical concepts test between the static infographics experimental group and the control group. To test these differences, one way ANOVA was performed at $p<0.05$ (Table 4).

Table 4 shows significant differences between the mean scores of the static infographics experimental group and the control group. The differences are in favor of the static infographics experimental group. It can be said that there is a significant difference ($p<0.05$) in academic achievement mean score on mathematical concepts test between the static infographics experimental group and the control group.

Scores of the animated infographics and static infographics

According to the results presented in Table 5, it can be said that there are differences between mean scores on mathematical concepts test between the interactive infographics experimental group and the static infographics experimental group. To test these differences, one way ANOVA was performed at $p<0.05$. The results of the analysis are shown in Table 6. From the results in Table 6, a significant difference ($p<0.05$) between mean scores of the interactive infographics experimental group and the static infographics experimental group is observed, the difference is on the

Table 1. Mean and standard deviation of the interactive infographics experimental group and the control group.

Concepts	Group	Number	Mean	Standard deviation
Triangle	Animated infographics	28	5.89	2.01
	Control	27	3.81	2.32
Addition	Animated infographics	28	5.61	1.40
	Control	27	3.44	1.69
Angle	Animated infographics group	28	6.39	1.69
	Control	27	4.63	2.29
Square	Animated infographics	28	6.68	1.56
	Control	27	3.15	1.90
Line segment	Animated infographics	28	5.00	1.49
	Control	27	2.67	1.69
Area	Animated infographics	28	4.50	1.17
	Control	27	3.59	1.67
Multiplication	Animated infographics	28	5.54	1.10
	Control	27	4.07	1.73
Subtraction	Animated infographics	28	5.14	0.89
	Control	27	4.00	1.57
Acute angle	Animated infographics	28	3.96	0.79
	Control	27	3.33	1.30
Right-angled triangle	Animated infographics	28	4.54	1.10
	Control	27	3.19	1.39
Squared numbers	Animated infographics	28	4.48	0.98
	Control	27	3.30	1.71
Square root	Animated infographics	28	4.00	0.86
	Control	27	2.89	1.48
Pythagoras theorem	Animated infographics	28	12.85	1.89
	Control	27	8.89	2.06

Table 2. One way ANOVA results of the interactive infographics experimental group and the control group.

Concepts	Source of variance	Sum of squares	Degree of freedom	Means of square	*F*	P
Triangle	Between groups	59.356	1	59.356	12.647	0.01
	Within groups	248.753	53	4.693		
Addition	Between groups	64.291	1	64.291	26.757	0.00
	Within groups	127.345	53	2.403		
Angle	Between groups	42.734	1	42.734	10.635	0.02
	Within groups	212.975	53	4.018		
Square	Between groups	171.322	1	171.322	56.923	0.00
	Within groups	159.515	53	3.010		
Line segment	Between groups	74.836	1	74.836	29.599	0.00
	Within groups	134.00	53	2.528		
Area	Between groups	11.318	1	11.318	5.477	0.02
	Within groups	109.519	53	2.066		
Multiplication	Between groups	29.366	1	29.366	14.045	0.00
	Within groups	110.816	53	2.091		
Subtraction	Between groups	17.953	1	17.953	11.138	0.02
	Within groups	85.429	53	1.611		

Table 2. Contd.

Acute angle	Between groups	5.472	1	5.472	4.757	0.03
	Within groups	60.964	53	1.150		
Right-angled triangle	Between groups	25.071	1	25.071	16.002	0.00
	Within groups	83.038	53	1.567		
Squared numbers	Between groups	31.972	1	31.972	16.656	0.00
	Within groups	101.737	53	1.920		
Square root	Between groups	28.208	1	28.208	19.473	0.00
	Within groups	76.774	53	1.449		
Pythagoras theorem	Between groups	904.315	1	904.315	231.91	0.00
	Within groups	206.667	53	3.899		

Table 3. Mean and standard deviation of the static infographics experimental group and the control group.

Concepts	Group	Number	Mean	Standard deviation
Triangle	Static infographics	27	6.19	1.66
	Control	27	3.81	2.32
Addition	Static infographics	27	5.41	1.34
	Control	27	3.44	1.69
Angle	Static infographics	27	6.67	1.49
	Control	27	4.63	2.29
Square	Static infographics	27	6.65	1.95
	Control	27	3.15	1.90
Line segment	Static infographics	27	4.96	1.95
	Control	27	2.67	1.69
Area	Static infographics	27	4.52	1.28
	Control	27	3.59	1.67
Multiplication	Static infographics	27	5.11	1.42
	Control	27	4.07	1.73
Subtraction	Static infographics	27	4.78	1.09
	Control	27	4.00	1.57
Acute angle	Static infographics	27	4.19	0.74
	Control	27	3.33	1.30
Right-angled triangle	Static infographics	27	4.15	1.17
	Control	27	3.19	1.39
Squared numbers	Static infographics	27	4.82	1.28
	Control	27	3.30	1.71
Square root	Static infographics	27	4.32	1.04
	Control	27	2.89	1.48
Pythagoras theorem	Static infographics	27	17.00	1.35
	Control	27	8.89	2.06

Table 4. One way ANOVA results of the static infographics experimental group and the control group.

Concepts	Source of variance	Sum of squares	Degree of freedom	Means of square	*F*	P
Triangle	Between groups	75.852	1	75.852	18.592	0.01
	Within groups	212.148	52	4.08		
Addition	Between groups	52.019	1	52.019	22.321	0.00
	Within groups	125.185	52	2.33		
Angle	Between groups	56.019	1	56.019	14.992	0.02
	Within groups	194.296	52	3.736		
Square	Between groups	156.741	1	156.741	42.434	0.00
	Within groups	192.074	52	3.694		
Line segment	Between groups	71.185	1	71.185	21.401	0.00
	Within groups	172.963	52	3.326		
Area	Between groups	11.754	1	11.754	5.222	0.02
	Within groups	115.259	52	2.217		
Multiplication	Between groups	14.519	1	14.519	5.784	0.00
	Within groups	130.519	52	2.510		
Subtraction	Between groups	8.167	1	8.167	4.486	0.002
	Within groups	94.667	52	1.821		
Acute angle	Between groups	9.796	1	9.796	8.772	0.034
	Within groups	58.074	52	1.117		
Right-angled triangle	Between groups	12.519	1	12.519	7.615	0.00
	Within groups	85.481	52	1.644		
Squared numbers	Between groups	18.963	1	18.963	8.330	0.00
	Within groups	118.370	52	2.276		
Square root	Between groups	16.667	1	16.667	10.236	0.00
	Within groups	84.667	52	1.628		
Pythagoras theorem	Between groups	212.019	1	212.019	69.746	0.00
	Within groups	158.074	52	3.040		

Table 5. Mean and standard deviation of the interactive infographics experimental group and the static infographics experimental group.

Concepts	Group	No.	Mean	Standard deviation
Triangle	Animated infographics	28	5.89	2.01
	Static infographics	27	6.19	1.66
Addition	Animated infographics	28	5.61	1.40
	Static infographics	27	5.41	1.34
Angle	Animated infographics	28	6.39	1.69
	Static infographics	27	6.67	1.49
Square	Animated infographics	28	6.68	1.56
	Static infographics	27	6.65	1.95
Line segment	Animated infographics	28	5.00	1.49
	Static infographics	27	4.96	1.95
Area	Animated infographics	28	4.50	1.17
	Static infographics	27	4.52	1.28
multiplication	Animated infographics	28	5.54	1.10
	Static infographics	27	5.11	1.42
subtraction	Animated infographics	28	5.14	0.89
	Static infographics	27	4.78	1.09

Table 5. Contd.

Acute angle	Animated infographics	28	3.96	0.79
	Static infographics	27	4.19	0.74
Right-angled triangle	Animated infographics	28	4.54	1.10
	Static infographics	27	4.15	1.17
Squared numbers	Animated infographics	28	4.48	0.98
	Static infographics	27	4.82	1.04
Square root	Animated infographics	28	4.00	0.86
	Static infographics	27	4.32	1.04
Pythagoras theorem	Animated infographics	28	12.85	1.89
	Static infographics	27	17.00	1.35

Table 6. One way ANOVA results for the first experimental group and the second experimental group.

Concepts	Source of variance	Sum of squares	Degree of freedom	Means of square	*F*	P
Triangle	Between groups	1.175	1	1.175	0.344	0.56
	Within groups	180.753	53	3.410		
Addition	Between groups	1.77	1	1.77	0.397	0.53
	Within groups	102.9725	53	1.943		
Angle	Between groups	1.031	1	1.031	0.406	0.52
	Within groups	134.679	53	2.541		
Square	Between groups	2.08	1	2.08	0.067	0.79
	Within groups	164.779	53	3.109		
Line segment	Between groups	3.696	1	3.696	1.016	0.31
	Within groups	192.741	53	3.637		
Area	Between groups	3.436	1	3.436	1.840	0.18
	Within groups	99.00	53	1.866		
Multiplication	Between groups	7.896	1	7.896	3.385	0.07
	Within groups	123.631	53	2.333		
Subtraction	Between groups	3.621	1	3.621	2.603	0.11
	Within groups	73.725	53	1.391		
Acute angle	Between groups	2.731	1	2.731	2.077	0.15
	Within groups	69.705	53	1.315		
Right-angled triangle	Between groups	3.945	1	3.945	2.461	0.12
	Within groups	84.963	53	1.603		
Squared numbers	Between groups	10.130	1	10.130	4.293	0.01
	Within groups	125.070	53	2.360		
Square root	Between groups	8.861	1	8.861	5.809	0.0.1
	Within groups	80.848	53	1.525		
Pythagoras theorem	Between groups	236.52	1	236.52	87.412	0.00
	Within groups	143.407	53	2.706		

following concepts: Squared numbers, square root and Pythagoras theorem. The differences are in favour of static infographics experimental group (based on THEPACT strategy). As a result of this analysis, it can be said that there is a significant difference ($p<0.05$) in academic achievement mean score on mathematical concepts test between the interactive infographics experimental group based on THEPACT strategy and the static infographics experimental group based on THEPACT strategy.

DISCUSSION

The results shown above has proven the positive impact of using infographics (static and animated) based on THEPACT strategy on developing mathematical concepts achievement. Using infographics based on the THEPACT strategy prompts female students to participate on all learning activities. This helps teachers and students to accomplish educational goals more effectively. Using infographics can also create a rich education environment with visual stimuli and sensory experiences. It was also noticed that students in the two experimental groups have more opportunities for social interaction which contributed to increasing and improving their motivation to learn, communicate and swap ideas in the classroom.

Representing concepts through infographics helps make abstract concepts more concrete. Using infographics features like colors, shapes, arrows and symbols helped to illustrate the mathematical concepts in a fascinating way. This way of representing concepts seemed more attractive for students than reading about it in textbooks. The findings of similar studies indicated that infographics help learners to cope with difficult and complicated information. It helps learners to understand courses' content and improves immediate and postponed academic achievement (Diezmann and Lowerie, 2010; Sudakov et al., 2014; Ching, 2013).

With regard to comparing between animated and static infographics, previous results revealed that illustrating new concepts for students, like squared numbers, square root and Pythagoras theorem, static infographics is easier for students to deal with, especially when learning new concepts. Meanwhile, the comparison between the two types of infographics did not reveal any significant difference for the rest of the concepts.

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