

The Use of Tangible User Interface in Interactive System to Learn about Countries

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Abstract—Tangible User Interface (TUI) is an interface that allows user to interact with digital information through physical environment. We have developed an interactive system serves the educational field within the geographical domain. The system allows children to discover and learn about countries from different continents using tangible objects. In our project we selected so far six countries that represent six continents in the world. The selected countries are: Saudi Arabia, Egypt, United States of America, France, Brazil, and Australia. With the system, children are required to manipulate tangible objects. Their task is to select a landmark from a country and placing it on the table top. The system will recognize the object and provides users with feedback. The system involves the recognition of six elements for each country: (capital, flag, climate, currency, population and industries). This application has been evaluated in a field study with children 9–11 years of age. The initial results are promising and show that such an interactive system can support interaction and collaboration among young children, as well as enriches the learning process and makes it more enjoyable.

Keywords—Tangible User Interface (TUI), Learning, Education, Geographic, Countries, edutainment, collaboration, Fun.

1 Introduction

New interactive systems such as mobile device, tablet, games and simulations, Tangible User Interface (TUI) have spread dramatically in the educational field. These systems allow interaction between user and digital information through physical objects. Using these systems for learning purpose can create an interactive environment that support edutainment for both students and teachers. Specifically, TUI support collaborative activities and promoted social learning process [4]. We propose in this paper to increase another technology to this range of products: Discover Countries interactive system (Figure 1).

We decided to use TUI concept that that allows users to interact with digital information through physical environment [8]. The proposed system are mainly based on reactIVision platform which is a computer vision framework for the fast tracking of fiducial markers attached onto physical objects [9]. The system detects objects

equipped with fiducial markers when they are placed on the table. Each object has a unique fiducial marker that allows the system to retrieve and display the data for each object. The system has six different objects represents the land mark for each country. Kaaba for Kingdom of Saudi Arabia, Amazon Theater for Brazil, Pyramid for Egypt, Opera house for Australia, Eiffel tower for France, and Statue of Liberty for United State for America (Figure 2). By placing an object on the table, basic information of the country will display on the computer screen with oral and visual feedback. Basic information include: climate, industries, population, flag, capital and currency).



Fig. 1. Discover Countries interactive system. Using Statue of Liberty object to display information about USA

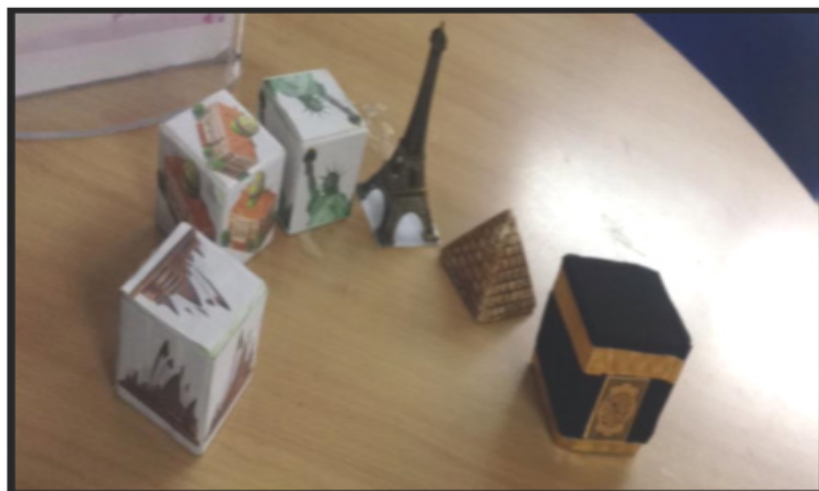


Fig. 2. The six objects (land marks) of the system

In recent years there has been an increasing development of interactive technology that promotes learning and play [13,14,7,6,18,1,10,2,11]. Discover Countries interactive system used in a school class with children to learn and recognize different countries and landmark from different continents. An empirical experiment was performed with 50 children to evaluate the affect of TUIs in children's learning environment. In this paper, we plan to propose design and architecture for the interactive table, as w. In addition, we will share the results of the experiment.

1.1 Learning with tangible technology

TUI attempt to take everyday objects and invest them with computation instead of sitting in front of a screen using a keyboard and a mouse to point and click on digital data.[5] shows that children are more productive when they cooperate with peers in a group of children and more able to do tasks in efficiently way. [12] Illustrates that learning with TUI supports conceptual metaphors and enhance learning for mathematics in young children. Scientists [3] suggest that TUI is a good solution for providing innovative ways for children to play and learn, through novel forms of interacting and discovering. Antle, propose a Tangible Learning Design Framework [15] argues that TUIs present unique opportunities to support learning interactions by reducing cognitive load and mappings between physical and digital objects.

Many studies [15,20,17,16] provides evidence of TUI benefits in learning with children in different domains, such as color, mathematics, chemistry, numbers, shapes, programming language and much more. However, little empirical work exists that provides evidence for enhanced learning geographic domain, especially in learning about countries, continents, and their famous landmark. Discover Counties interactive system develop to enrich the learning process and makes it more enjoyable within the geographical domain. It design by providing the users an over control of the system in a digital space, while matching between the real world and the digital one.

2 The Tabletop as Learning Interface

Discover Countries interactive system is a table-top, tangible user interface with which to interact with physical objects and present information. We are developing a system that includes software that enables users to transform tabletop physical objects into interactive tokens. Our setup is adopted from [2] which consist of a transparent box that has useful tabletop surface, webcam, and everyday objects that are tagged with fiducial markers. The fiducial markers attached at the bottom of the objects can be recognize by a webcam, and manipulating the objects creates and alters information and feedback that are displayed on screen.

2.1 How does it work?

The bottom of each landmark is attached with a fiducial marker specially designed to be identified by the reactIVision platform [9]. The web camera placed below the table captures the image of the fiducial markers in real time. The reactIVision recognizes the ID of each identified marker while this information is interpreted by the TUIO protocol. TUIO protocol is adopted for encoding the state of tangible objects from our interactive tabletop, and then transfer it into our system's software. The system software developed by Processing 1programming sketchbook (Figure 3).

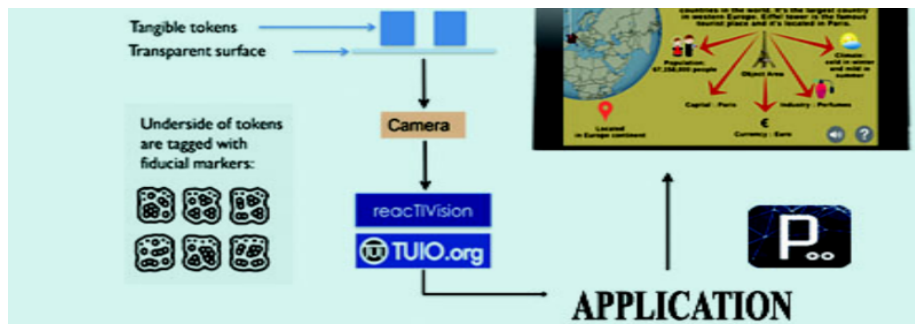


Fig. 3. A schema clarify how does the system work

3 Experimental Design and Evaluation

We conducted a user study in a private school located at Jeddah, Saudi Arabia. 50 students participated in the testing process. The students are in the age group of 9-11 (all are girls). The students are vary between third, fourth and fifth grades.

The prime goal of this study is to comprehend that using TUI improve children learning. In particular we are interested in:

- Does Discover Countries interactive system enhance children collaboration?
- Does Discover Countries interactive system support playfulness while learning?
- Students achievements “grades” after using the system
- The time taken to answer the questions?

3.1 Experiment procedure

Sessions took place in children classroom, while noise levels and distraction were on control. There were five children per each session. Sessions lasted between twelve and twenty minutes. It was then explained in general terms that the goal of the study was to find out what help children learn about countries. At first, all groups asked to answer questions about some countries information such as: capital, flag, currency,

¹ Processing (2014) Processing Software and Language. Available at: <https://processing.org/>

weather, and landmark. We called this session DegreePre. Students answer the questions using paper and pencils. After that, each group asked to play with the system.

The researchers sit the landmark objects on a table and asked the students to place the landmark on the interactive system table. While the land mark on top of our system's table, the information of the country is displayed on the laptop's screen, see Figure 4 . Each group should try all the six land marks.

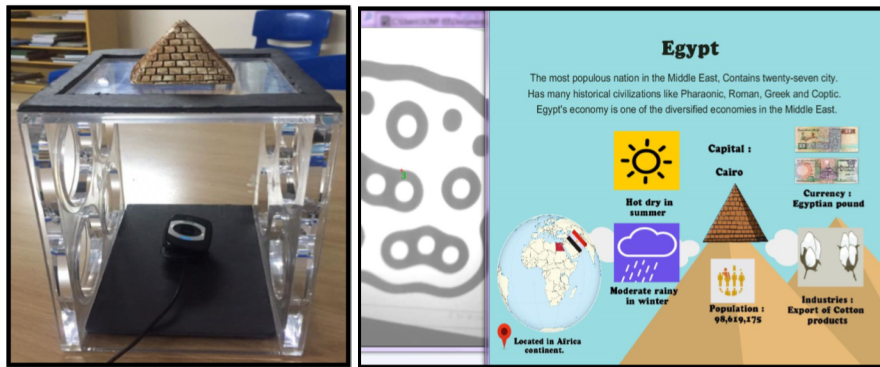


Fig. 4. On the right placing pyramid object on the table. On the left information about Egypt is displayed on the screen.

Later than, all groups were asked to answer questions about some countries information such as: capital, flag, currency, weather, and landmark. It was different questions than the one in the Degree Pre-session. We called this session Degree Post.

3.2 Test hypotheses

The 'null hypothesis' might be:

- **H0:** There is no difference in mean pre- and post-grades

An alternative hypothesis' might be:

- **H1:** There is a difference in mean pre- and post-marks. See Figure 5

The relevant results for the paired t-test:

We observe the t statistic, $t = -5.081$, and $p = 0.00$.

The null hypothesis is rejected, since $p < 0.05$ (in fact $p = 0.00$).

Linear Regression Analysis The regression analyses for the post degree as independent factor, with time, collaboration and age as dependent factors. See Figure 6

There are two dependent factors that affect the degree “grade”, which are collaboration and age. The collaboration $t = 2.134$, and $p = 0.038$, and age $t = 6.288$, and $p = 0.000$. The null hypothesis is rejected, since $p < 0.05$ (in fact collaboration $p = 0.038$ and age $p = 0.000$).

In addition, after the students finished using our TUI system we asked them to fill the evaluation form. The purpose of the evaluation form is to test the usability factors of the interactive system as well as to ensure that the system is error free. See Table 1.

Paired Samples Statistics				
	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 DegreePre	3.34	50	1.272	.180
DegreePost	4.0400	50	1.06828	.15108

Paired Samples Correlations			
	N	Correlation	Sig.
Pair 1 DegreePre & DegreePost	50	.666	.000

Paired Samples Test									
		Paired Differences				t	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
Pair 1	DegreePre - DegreePost	-.70000	.97416	.13777	-.97685	-.42315	-5.081	49	.000

Fig. 5. Paired T-Test

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-7.055	1.895		-3.722	.001
	TimePost	.210	.211	.125	.997	.324
	CollaborationPost	.492	.231	.213	2.134	.038
	Age	.927	.147	.784	6.288	.000

a. Dependent Variable: DegreePost

Fig. 6. Linear regression

Table 1. The evaluation and assessment form of Discover Countries Interactive System

Question	Answer	Total	Average
Does the overall system is attractive?	Yes	50	100%
	No	0	0%
	Somehow	0	0%
Does the system have a good balance of text?	Yes	45	90%
	No	0	0%
	Somehow	5	10%
The information is easy to read?	Yes	43	86%
	No	2	4%
	Somehow	5	10%
Do you like to use again?	Yes	42	84%
	No	2	4%
	Somehow	6	12%
Do you like the system?	Yes	47	94%
	No	0	0%
	Somehow	3	6%
Does the colors used in the system are attractive?	Yes	47	94%
	No	0	0%
	Somehow	3	6%

The results show high acceptance of the system from the students with good percentage of usability factors.

4 Conclusion

Many researchers have suggested that tangible user interface (TUI) have significant impacts on learning. It promotes collaboration, exploratory and expressive activities, offer learning of abstract concepts through concrete representations and allow embodied interaction. However, little empirical work exists that provides evidence for enhanced learning in geographic domain, specifically for learning about countries and its basic information by young children (9-11 years). Our study has shown that children can identify more county using landmark objects. At the same time, children were able to clarify country’s flag, capital, and currency more easily using Discover Country interactive system than using a book. We can say that using TUI with children improve their learning about different countries. As well as, it improves their collaboration and raises their motivation to learn more about countries.

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