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Complementing Multimedia with Tangible Objects as a Way to Stimulate Preschoolers' Motivation in Learning

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Abstract: An apparent problem noticeable in multimedia system nowadays is the absence of appropriate design strategies that rightly kindle preschoolers' motivation to learn. The primary force behind a person in pursuit of academic learning is motivation. The success or failure of any of the academic learning tasks is closely correlated to motivation. Therefore, multimedia systems that are adapted to stimulate motivation are of essential, particularly for those aimed at children who have vast different behaviour and preferences. Educators have been searching for strategies or approach to the generation of a motivated multimedia. In response to this, we conceived possible strategies to supplement preschoolers' motivation in multimedia learning. That is, by including Attention, Relevance, Confidence and Satisfactory, four design strategies of motivation prescribed by Keller (2010) into the multimedia system via the deployment of tangible objects. A relevant prototype named as *MotivaLearn* had been developed for investigation. The finding results renders us the feasibility of such multimedia. This paper discusses how the four strategies of motivation were applied on multimedia, followed by conclusion drawn from statistical analyses which revealed that the *MotivaLearn* improved 248 preschoolers' learning motivation significantly more than conventional multimedia.

Key words: Multimedia · Preschooler · Tangible multimedia · Motivation · Tangible Objects

INTRODUCTION

There is a growing concern about the difficulties of learning words in English as second language (ESL) amongst Malaysian preschoolers, whom rarely or do not speak English at home. The difficulty may due in part to their innate traits such as ease of distractibility, poor concentration, short attention span [1] and in part due to the use of the means of instruction that fail to take into account the factor of motivation adapted to preschoolers' innate requirements. This concern prompts an imperative need to intensify research to search for possible strategy or approach to the generation of a motivated multimedia to supplement preschoolers' motivation in ESL learning.

In response to the concern, we conceived a prototype of multimedia system named *MotivaLearn* and a relevant research on search for evidence of the efficacy of such multimedia. Different from the past research works on educational technologies, the research attempted a unique approach to manifest the motivation in multimedia learning. That is, tangible objects were deployed in *MotivaLearn* in order to realise a motivation model prescribed by Keller [2].

As a newly explored area, incisive description from its design on how tangible objects could be applied in multimedia to instigate and sustain motivation, down to reporting of empirical experiment of *MotivaLearn* is covered in adequate detail in this paper. Of specific importance of such research was to identify the degree of motivation the preschoolers stimulated from the system that bring the part of the world, tangible objects, into multimedia context, which could then determine the real value of such system.

Tangible Objects as a Way to Stimulate Motivation: Motivation signifies the internal psychological state of an individual's willingness, desire and commitment in the pursuit of specific goals [2]. ARCS model of motivation was adopted as the theoretical framework for designing motivating multimedia in the research. It posits Attention, Relevance, Confidence and Satisfaction (ARCS) as the four essential motivational design strategies [2].

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That is to say, if a system contains strategies that are able to capture a person's "attention", "relevant" to the person's needs, convincing that one could succeed after learning and satisfactorily rewarded, then the person will be motivated to use it and learn from it.

Tangible object is regarded as physical object that is electronically bound to digital multimedia objects. It was the means deployed to trigger the motivation of young children in digital multimedia.

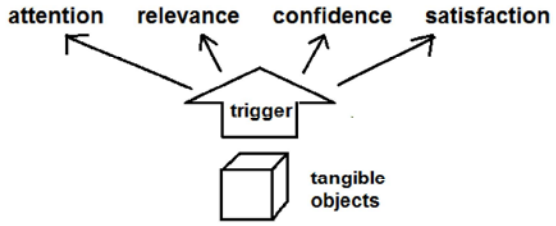

Fig. 1: Tangible virtual objects as a means to realise the ARCS in *MotivaLearn*

Animations and videos are no longer accounted for motivational elements in digital multimedia because children nowadays have been overly exposed to digital media [3, 4], causing young children no longer felt video and animation that much fun in their mind. The following sections further illustrate how tangible objects could practically enable new forms of motivational interface set up within multimedia context in *MotivaLearn*.

How Tangible Objects capture "Attention" of Preschoolers: In *MotivaLearn*, tangible objects were positioned openly and irregularly on display table in front of the preschoolers. Such strategy provided a lively environment to arouse attention and interest of the preschoolers. Their attention was then sustained through the ways that first, tangible objects were displayed constantly the entire time during the learning session. Second, mandatory gestural performance on tangible objects that demand deliberate efforts were required to explore and trigger virtual learning contents.

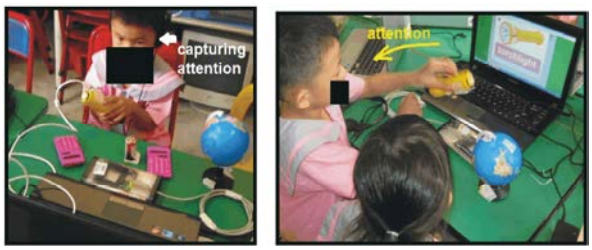

Fig. 2: Open and irregular way of tangible objects arrangement captured the attention of preschooler

In reality, tangible objects can be utilised in more variety of ways to further capture preschoolers' attention. Besides designated to present learning contents, it can also be used as explanatory objects, resources utilities, additional aids, decorative objects, educative toys which are all appealing to young children, or figurines that could satisfy their nature of play.

How Tangible Objects arouse "Relevance" to Preschoolers: Authentic virtual surroundings that bear a resemblance to real-life environment of Malaysia were adopted as contextual background in each learning session of *MotivaLearn*. Tangible object itself denotes a real-world concrete material. By associating it meaningfully to be part of the overall environment, *MotivaLearn* delivered not only a culturally- and socially-relevant environment that was attuned to the learners' personal situation and needs, but also a familiar setting that could elicit natural responses from the preschoolers. In contrast to learning in isolation, the preschoolers could therefore internalise the learning goal, engage in an emotional bond with the content in the learning scene and comprehend the real uses of the objects more effectively. Evidences reveal that children learn language well when learning materials are situated and presented in meaningful contexts [5, 6].

How Tangible Objects build up "Confidence" for Preschoolers: A positive expectation for successful achievement motivates the pursuit of learning while insurmountable challenge circumvent them from continuing. Tangible objects are the natural way of learning for the children. Minimal training required for hands-on manipulation and gestural movement build up the confidence of success amongst preschoolers. In addition, setting individual tangible objects as learning unit implicated a way of "fractionation" of learning process into small units. A smaller unit of a learning task enable the learners to know whether they succeeded or not.

Fig. 3: Pairing of preschoolers in learning process

The capability of tangible objects to be shared further building up the confidence of preschoolers. *MotivaLearn* was designed with the requirement of pairing of subjects. By sitting side by side, the subjects could pass around the tangible objects collaboratively in *MotivaLearn*. Children prefer to work in the company of a friend [7]. Therefore, setting of learning alongside each promoted a higher level of confidence.

How Tangible Objects evoke "Satisfaction" to Preschoolers: Two ways tangible objects in *MotivaLearn* evoke the sense of satisfaction amongst preschoolers. First, graspable tangible objects themselves recruit the "feltness" of digital objects. Piagetian theories on cognition development states young children learn best when touching senses are included in their learning process. Second, as a result of the learning experience, rewards were given in the form of points after success in Quiz session that had to be answered by picking tangible objects. Due to this, satisfaction gained in *MotivaLearn* can be categorised both for intrinsic purpose, a satisfaction due to sense of achievement and extrinsic purpose, which is the need for reward and entertainment.

Fig. 4: Reward for preschoolers in Quiz gives satisfaction to preschoolers

Objectives of the Research: The research is purported to investigate the extent the *MotivaLearn* system, a manifestation of multimedia unified with tangible objects, influence the motivation level of Malaysian preschoolers.

Research Questions (RQ): The research sought to answer the following Research Questions (RQ):

RQ1. Do learners of the *MotivaLearn* system demonstrate a significant difference in their motivation (as measured by PMMS score) compared to the learners engaged in conventional multimedia system?

RQ2. Is there any interaction effect in each of the motivation between learners in the *MotivaLearn* group as compared to the conventional multimedia group with different cognitive style (field-dependent and field-independent learners)?

RQ3. Is there any significant difference in each of the motivation between learners in the *MotivaLearn* group as compared to the conventional multimedia group with different cognitive style (field-dependent and field-independent learners)?

Research Hypotheses: It was presumed that the experimental system incorporated with new attribute has null effects on the learners. The level of significance of the research, $\alpha = 0.05$.

$H_0$1: There is no significant difference in motivation between learners using *MotivaLearn* and those using conventional multimedia system.

$H_0$2: There is no interaction effect between the learning modes (*MotivaLearn* and conventional multimedia systems) and cognitive style (field-dependent and field-independent learners) on motivation.

$H_0$3: There is no significant difference in motivation between field-dependent and field-independent learners in the *MotivaLearn* and conventional multimedia groups.

On the whole, the research seeks to answer RQ1, RQ2 and RQ3 to confirm whether there are significant differences in the dependent variables between field-dependent and field-independent learners of each type of learning mode.

System Design: *MotivaLearn* is a regular multimedia system unified with tangible objects electronically. Other constituting components are display table, mice, earphones and virtual objects on screen. The display table conveniently provided a space for tangible objects placement and pairing of subjects.

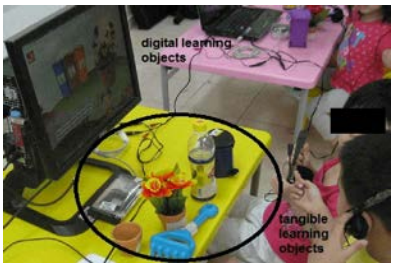

Fig. 5: Tangible and virtual learning objects in *MotivaLearn*

In seven days of treatment using experimental system, the learning process was started off with the subjects selecting, holding and performing gestural movement on tangible objects that situated around virtual learning objects on computer screen to trigger presentation of multimedia contents for conceptualisation. These virtual objects, which were electronically tied to tangible objects as well, aimed at imparting educational content about the objects to the preschoolers. The entire learning process ended by the subjects participating in quiz session.

In regards to the implementation of *MotivaLearn*, the researchers had devoted two years to explore, test, design and develop a number of different versions of working prototypes of *MotivaLearn* using numerous types of technology, from image processing, visual marker technology, to RFID and sensing technology. The chronology of development is illustrated in Figure 6.

1	Web camera with Image processing detection algorithm using Microsoft DOT NET *C#*		• Developed before pilot study. • Discarded because of lighting condition requirement for detection. • Not feasible for a system that requires many objects recognition.
2	QR code marker using *Flash ActionScript* 3.0		• Deployed for evaluation in pilot study 1. • Discarded because 1) difficulty in detection 2) precise alignment to camera required. 3) huge marker attached on objects blocking view.
3	RFID and sensor devices using *Phidget* Library		• RFID using Microsoft .NET C# language was initially developed, but discarded because of difficulty to integrate with *Flash* animations. • RFID and sensor devices using *Phidget* Library were tested in pilot study 2. Found better because it shipped with *Flash* library that made integration with animation and *ActionScript 3.0 programming* easier.

Fig. 6: Technologies attempted for digital-virtual binding

Considering the choice of technology should rest on its usefulness to the preschoolers as learning aids, the researchers decided to deploy RFID and sensor devices (force, spatial, touch sensors, as well as electronic sliders). They were inserted directly into the tangible objects.

Research Instruments: CEFT (Children's Embedded Figure Test): An instrument deployed to identify the cognitive style of a subject in the dimension of field-dependence or field-independence. The research followed the standard protocols of CEFT where the subjects were required to demonstrate their level of perceptual competence in disembedding figures embedded within more complicated pictures within 30-minute time frame. The subjects who scored less than 11 points are categorised as field-dependent whereas subjects with score more than 11 points are designated as field-independent. The CEFT was utilised because first, it can be presented in the form of a game, which is highly suitable for young subjects in the research. Second, the reliability ratios of the CEFT for children from the ages of 5 to 12 years were 0.84 to 0.90. In Malaysia, a high reliability of 0.87 in Sabrina's [8] research was reported.

Fig. 7: CEFT test in progress

PMMS (Persuasive Multimedia Motivational Scale): An instrument utilised to measure the motivation level of the subjects [9]. It comprises ten Likert-based questions requesting perception whether the experimental systems were easy and interesting. The reasons the PMMS was selected because first, the Cronbach alpha coefficient for the reliability of the PMMS was satisfactorily reliable [9]. Second, smileys in PMMS are child-friendly to young children. Five different representations of smileys were used to represent five levels of motivation. A response of 5 (strongly agree) means a high level of motivation whereas 1 (strongly disagree) indicates zero motivation.

Fig. 8: PMMS test in progress and sample of PMMS

Overview of Dataset: Table 1 reports the statistics of subjects in the research. A total of 248 preschoolers were recruited for experimental classes. They were derived randomly from a pool of the entire population of seven kindergartens, of which 128 (51.6%) were exposed to *MotivaLearn* treatment whereas 120 (48.4%) control treatment. In regards to cognitive style distribution, 127 (51.2%) were field-dependent and 121 (48.8%) field-independent subjects.

Table 1: Statistics for IVs and MVs for each cell in the research

	Variable	Frequency (N=248)	Percentage (%)
Learning Mode	*MotivaLearn*	128	51.6
	Conventional multimedia	120	48.4
Cognitive Style	Field-dependent	127	51.2
	Field-independent	121	48.8

Table 2 reports different sizes of cell based on the learning modes. There were 59 field-dependent and 69 field-independent subjects utilised the *MotivaLearn* while 68 field-dependent and 52 field-independent subjects used the conventional multimedia.

Table 2: Statistics for cognitive style by learning mode (IV)

	Learning mode	
	MotivaLearn	conventional multimedia
Cognitive style	(n_T = 128)	(n_{CMM} =120)
Field-dependent	59 (46%)	68 (57%)
Field-independent	69 (54%)	52 (43%)
Total	128	120

Testing Assumptions for Mancova: Quantitative data analysis using SPSS was the primary analysis method employed in the research. Priori examination of dataset had been carried out to ensure the dataset satisfy the assumptions.

Appropriateness of Dataset: The dataset were appropriate for MANCOVA analyses because first, each subject appeared under only one learning mode to ensure undesirable interaction between cells was avoided. Second, each cell has n>30. The ratio of the smallest sample variance to the largest did not exceed the ratio of 1:1.5 on the range of variables tested, thereby acquiring a balanced ratio of subjects [10]. Third, there is reasonable normality of dataset. Skewness and Kurtosis statistical values for each DV were between -1.0 and +1.0. Motivation has a mean ($\bar{X}$) of 70.42, 11,73 of standard deviation (SD), 0.240 of Skewness and -0.382 of Kurtosis.

Testing of Hypotheses: In view of absence of major violation of the assumptions of MANCOVA, the researchers can continue with MANCOVA confidently. The main effects are tested at an alpha level of 0.05. Each simple effect, if any, are tested at an α level of 0.017 (0.5 divided by three univariate tests), making use of the Bonferoni adjustments [11] to take into account the family-wise error so as to guard against inflating Type I error [12].

The Main Effect of Learning Mode: The main effect of the two learning modes, *MotivaLearn* and conventional multimedia on the DV is analysed and presented based on the following hypothesis:

H_o1There is no significant difference in motivation between learners using the *MotivaLearn* and those using conventional multimedia mode.

Descriptive Statistics Analysis of the Effects of Learning Mode on the Dependent Variable (DV): Table 3 provides the motivation scores of both *MotivaLearn* and conventional multimedia treatments in descriptive statistics.

Table 3: Mean scores ($\bar{X}$) and standard deviations (SD) of DV by learning mode

	Mode	$\bar{X}$	SD	difference of $\bar{X}$
Motivation	*MotivaLearn*	74.50	10.64	8.42
	conventional multimedia	66.08	11.31	

MotivaLearn results in higher $\bar{X}$ of motivation score ($\bar{X}$ =74.50; SD=10.64) than conventional multimedia subjects ($\bar{X}$ =66.08; SD=11.31) by 8.42. It is therefore concluded that H_o1 was rejected.

The Interaction Effects for Cognitive Style and Learning Mode

The Hypothesis Tested Were:

H_o2: There is no interaction effect between the learning modes (*MotivaLearn* and conventional multimedia) and cognitive style (field-dependent and field-independent) on motivation.

The Interaction Effects between Cognitive Style and Learning Mode on the Motivation Score: Descriptive statistics of Table 4 reveals that the average motivation scores achieved by all field-dependent and field-independent subjects from both conventional multimedia and *MotivaLearn* differ by 1.5 (71.18-69.68), with field-independent subjects doing better. *MotivaLearn* did better than conventional multimedia with difference of 8.2 (74.53-66.33).

Table 4: Descriptive statistics (mean scores ($\bar{X}$) and standard deviations (SD)) of motivation score by learning mode and cognitive style

	Learning mode		
Cognitive style	conventional multimedia ($\bar{X}$)	*MotivaLearn* ($\bar{X}$)	Average
Field-dependent	64.50	74.85	69.68
Field-independent	68.15	74.20	71.18
Average	66.33	74.53	

Figure 9 provides visual description of the effects for cognitive style and a main effect of learning mode. The crossing lines in the figure are indicative of interaction effect.

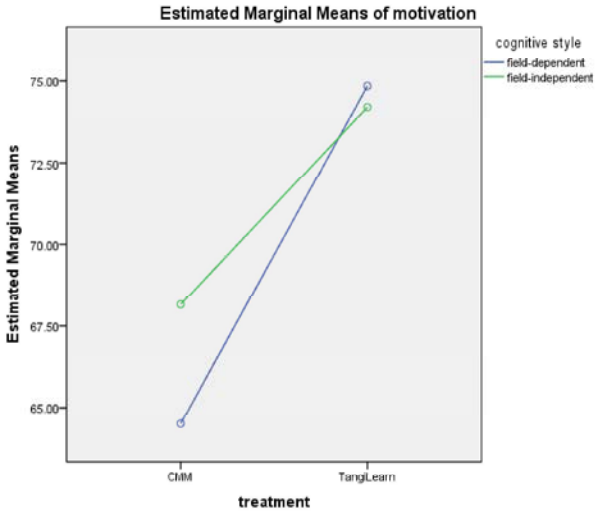

Fig. 9: Plot of effects on motivation between learning mode and cognitive style

Inferential statistical test to discern the pattern of main and interaction effects is shown in Table 6.

Table 6: Analysis of main and interaction effects of cognitive style and learning mode on motivation score

Tests of Between-Subjects Effects

Dependent Variable: motivation

source	type III sum of squares	*df*	mean square	*F*	*Sig.*
Corrected Model	4794.138[a]	3	1598.046	13.351	0.000
Intercept	1213811.689	1	1213811.689	10141.228	0.000
CEFT	138.513	1	138.513	1.157	0.283
learningmode	4112.136	1	4112.136	34.356	0.000
CEFT x learningmode	282.605	1	282.605	2.361	0.126
Error	29204.556	244	119.691		
Total	1264084.000	248			
Corrected Total	33998.694	247			

a. R Squared=0.141 (Adjusted R Squared=0.130) b. Computed using alpha=0.05

The main effect of cognitive style on motivation score was not significant ($F(1,244)=1.157$, $p=0.283$). The main effect of learning mode was significant ($F(1,244)=34.356$, $p=0.001$). There was a non-significant interaction effect between cognitive style and learning mode ($F(1,244)=2.361$, $p=0.126$), signifying that no difference for field-dependent subjects than it was for field-independent subjects in motivation enhancement using the *MotivaLearn*. In this respect, the H_o2 hypothesis was accepted.

The Difference of Dependent Variables by Cognitive Style: This section analyses the difference of the DV by cognitive style at each level of learning mode. The hypotheses tested are as follows:

H_o3: There is no significant difference in motivation between field-dependent and field-independent learners in the *MotivaLearn* and conventional multimedia groups.

Analysis of The Difference Of Dependent Variables By Cognitive Style In Learning Mode: The statistical analysis in Table 7 reports the large mean differences of motivation between the field-dependent subjects in conventional multimedia and *MotivaLearn* (-10.347) and between the field-independent subjects in conventional multimedia and *MotivaLearn* (-6.049).

Table 7: Pairwise comparisons analysis of the difference of the motivation score between subjects of different cognitive style in learning mode

Dependent Variable: motivation					
Cognitive style	(I) treatment	(J) treatment	mean difference (I-J)	std. error	*Sig.*[a]
Field-dependent	conventional multimedia	*MotivaLearn*	-10.347*	1.946	0.000
Field-independent	conventional multimedia	*MotivaLearn*	-6.049*	2.009	0.003

* The mean difference is significance at the 0.05 level. a. Adjustment for multiple comparisons: Bonferroni.

Table 8: Univariate analysis of the difference of the motivation score between subjects of different cognitive style in learning mode

Dependent Variable: motivation						
Cognitive style		sum of squares	*df*	mean square	*F*	*Sig.*
Field-dependent	Contrast	3382.397	1	3382.397	28.259	0.000
	Error	29204.556	244	119.691		
Field-independent	Contrast	1085.030	1	1085.030	9.065	0.003
	Error	29204.556	244	119.691		

Analyses of inferential statistics in Table 8 reveal *MotivaLearn* led to significant higher motivation scores for field-dependent subjects than conventional multimedia field-dependent subjects ($F(1,244)=28.259$, $p<0.001$) and for field-independent than conventional multimedia field-dependent subjects ($F(1,244)=9.065$, $p=0.003$). It is thus concluded that H_o3 was rejected.

Summary of the Testing Results of Hypotheses: The results of the hypotheses tested are summarised in Table 9:

Table 9: Summary of the testing results of hypotheses

Hypotheses		Decision	General implications
H_o1	There is no significant difference in motivation between *MotivaLearn* learners and conventional multimedia learners.	reject	*MotivaLearn* is able to enhance preschoolers' learning motivation more than conventional multimedia. *MotivaLearn* could serve as alternative to conventional multimedia.
H_o2	There is no interaction effect between the learning modes (*MotivaLearn* and conventional multimedia) and cognitive style on motivation.	fail to reject	*MotivaLearn* is suitable for both field-dependent and field-independent preschoolers in motivation.
H_o3	There is no significant difference in motivation between field-dependent and field-independent learners in the *MotivaLearn* and conventional multimedia groups.	reject	*MotivaLearn* enhances field-dependent and field-independent preschoolers' motivation more than conventional multimedia.

DISCUSSION ON THE FINDING OF THE DATASET

The Main Effect on Motivation: The *MotivaLearn* mode had significant positive main effect on motivation. It had affected the subjects significantly to gain higher PMMS scores than conventional multimedia subjects. A conclusion is therefore drawn that the strategy used in *MotivaLearn* was eminently successful in kindling motivation of subjects towards ESL learning. Such positive effect suggests the chances that the subjects will continue to use, or reuse *MotivaLearn* for more learning in future.

Ability to perform effortless "navigation" using tangible objects along the *MotivaLearn* mode provides one of the plausible explanations to the positive effect. Tangible objects in hand serving as scaffolding tool for navigation had built up the young children's confidence and satisfaction. Perception of easy to use motivated them to further explore the *MotivaLearn.* In regards to conventional multimedia, digital presentation had declined the subjects' motivation due to non-existence of opportunity of grabbing and sharing, as required in the cognition of young children engaged in learning [13].

High degree of authenticity and relevancy of realistic element within contextualised learning materialised by the tangible objects in *MotivaLearn* also serves as a viable explanation. The "relevance" component of ARCS motivation theory states that learners shown with items in real setting that are highly relevant and useful to them in learning is a way to motivate them [2]. This is because a learner remembers what have been learned is by having similar experiences in an instruction that trigger the learner's memories [14]. The motivation for conventional multimedia subjects declined due to difficulty in triggering their memories in non-relevant environment.

Interaction Between Cognitive Style and Learning Mode on Motivation: The interaction effect between the subjects' cognitive style and learning modes on motivation score is not significant. This indicates that first, the cognitive style of a subject did not moderate the strength of the relationship between learning mode and motivation. Second, motivation enhancement in *MotivaLearn* was not dependent on cognitive style, which means *MotivaLearn* is suitable for motivating both field-dependent and field-independent subjects.

Cross comparison of learning modes by cognitive style in motivation reports a significant difference between field-dependent subjects in *MotivaLearn* and conventional multimedia and between field-independent subjects in both *MotivaLearn* and conventional multimedia. Field-dependent subjects in *MotivaLearn* motivated significantly better than field-dependent subjects in conventional multimedia. Similarly, field-independent subjects in *MotivaLearn* significantly motivated better than field-independent subjects in conventional multimedia. This evidences that *MotivaLearn* brings motivated experiences to both field-dependent and field-independent subjects simultaneously.

Generally, field-independent subjects were initially expected to be motivated better in an unstructured and explorative environment. For field-dependent subjects,

who were more customary to teachers' guidance and assistance [15], were expected to be motivated better in structured and linear environment. However, the finding shows differently. Both cognitive styles of subjects were observed to be motivated in ESL learning. While motivation was kindled amongst the field-independent subjects, *MotivaLearn* did not demotivate field-dependent subjects. This could be attributed to the situation that the learning process in *MotivaLearn* was started off appropriately at the early stage of learning. By commencing learning with sensorial grabbing, the preschoolers' learning curve was therefore attuned into the right learning tempo.

Implications of the Research: As *MotivaLearn* has motivational advantages over conventional multimedia system, kindergartens in Malaysia may be encouraged to consider using *MotivaLearn* for self-directed learning among preschoolers. Motivation advantage alone is sufficient to convince teachers to consider using it. This is because when motivation is increased, an attitude of inquiry as suggested by Keller [16] can be stimulated, thereby interest and goals arouse for continuing self-exploration.

CONCLUSION

The research sought to develop a motivated multimedia system aimed at preschoolers. The finding results demonstrated that both field-dependent and field-independent subjects were positively motivated towards *MotivaLearn* more than conventional multimedia. This alludes that tangible objects are indispensable in multimedia context in bringing motivation benefits to preschoolers of different cognitive style. Statistical comparison analyses reveal that field-dependent and field-independent subjects were equally motivated with the *MotivaLearn* treatment. For this reason, it can be concluded that *MotivaLearn* provides a learning conducive environment for motivation by accommodating different personal trait and character pattern.

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