A Study of an Emerging Input Device Using Behavior

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Abstract**—**The purpose of this study was to assessing elementary students with the using of a new computer input device. The computer input device is important because of its function as a vehicle transfer users commands or wills to computer. Whenever a new device came into market, there is a need to explore its feasibility in educational usage so can be considering applications in educational fields. This study mainly focused on the input device called "Leap motion" and based upon the theory of planned behavior, TPB, the investigation of 24 elementary students was conducted to assessing their technology device using behavior. The TPB model provides a framework for understanding and predicting behavior in specific context and offered a useful platform for exploring device using intentions toward applying this new device in educational computing for elementary students.

Keywords**—**Emerging Input Device, Leap Motion, TPB

I. Introduction

In this Information Age, learners have at their enormous amounts of learning activities experienced the information computer technology, ICT, used in the educational environments. These ICTs are designed for the well-organized selection, storage, and retrieval of data, and are vital for learners to construct and keep track of their knowledge formations.[1-7] All the ICT instruments require communicate users with certain input and output devices.

The purpose of this study was to assessing the possibility of applying the new input device, Leap Motion, in elementary education. Based upon a reliable behavior predicting model, TPB, an investigation research method was adopted to exploring students' intention in using the Leap Motion device.

A computer input device is important because of its function as a vehicle transfer users commands or wills to computer. Whenever a new device came into market, there is a need to explore its feasibility in educational usage so can be considering applications in educational fields.

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II. I/O Device and behavior

Aggregating data into levels at which patterns can come into view, ordering levels into hierarchies to support drilling down and up through the levels, and using investigative functions such as lag, moving total, and year-to-date are among the techniques used to transform data into information. This information can provide a major boundary in a competitive marketplace.[8]

The computing literature often draws a sharp distinction between input and output; computer scientists are used to regarding a screen as a passive output device and a mouse as a pure input device. However, nearly all examples of human-computer interaction require both input and output to do anything useful. For example, what good would a mouse be without the corresponding feedback embodied by the cursor on the screen, as well as the sound and feel of the buttons when they are clicked? The distinction between output devices and input devices becomes even more blurred in the real world. A sheet of paper can be used to both record ideas (input) and display them (output). Clay reacts to the sculptor's fingers yet also provides feedback through the curvature and texture of its surface. Indeed, the complete and seamless integration of input and output is becoming a common research theme in advanced computer interfaces such as ubiquitous computing [9] and tangible interaction [10].

Input and output bridge the chasm between a computer's inner world of bits, and the real world perceptible to the human senses. Input to computers consists of sensed information about the physical environment. Familiar examples include the mouse, which senses movement across a surface, and the keyboard, which detects a contact closure when the user presses a key. However, any sensed information about physical properties of people, places, or things can serve as input to computer systems. Output from computers can comprise any emission or modification to the physical environment, such as a display (including the cathode ray tube, flat-panel displays, or even light emitting diodes), speakers, or tactile and force feedback devices. An interaction technique is the fusion of input and output, consisting of all hardware and software elements, that provides a way for the user to accomplish a low-level task. For example, in the traditional graphical user interface, users can scroll through a document by clicking or dragging the mouse (input) within a scroll bar displayed on the screen (output). There is a need to explore humans' behavior of all these I/O devices, so can ensure well communication constructed in an educational environment.

A. I/O Devices of ICT

Technology education is a subject of studying technology in which learners could learn about the context, process, and knowledge related to technology[11]. Technology education is all about learning technology literacy.

The primary task of human-computer interaction is to shuttle information between the brain of the user and the silicon world of the computer. Progress in this area attempts to increase the useful bandwidth across that interface by seeking faster, more natural, and more convenient means for users to transmit information to computers, as well as efficient, salient, and pleasant mechanisms to provide feedback to the user. On the user's side of the communication channel, interaction is constrained by the nature of human attention, cognition, and perceptual-motor skills and abilities; on the computer side, it is constrained only by the technologies and methods that we can invent. Research in input and output centers around the two ends of this channel:

1. The devices and techniques computers can use for communicating with people, and
2. The perceptual abilities, processes, and organs people can use for communicating with computers.
3. It then attempts to find the common ground through which the two can be related by studying new modes of communication that could be used for human-computer interaction (HCI) and developing devices and techniques to use such modes. Basic research seeks theories and principles that inform us of the parameters of human cognitive and perceptual facilities, as well as models that can predict or interpret user performance in computing tasks.

Advances can be driven by the need for new modalities to support the unique requirements of specific application domains, by technological breakthroughs that HCI researchers attempt to apply to improving or extending the capabilities of interfaces, or by theoretical insights suggested by studies of human abilities and behaviors, or even problems uncovered during careful analyses of existing interfaces. These approaches complement one another, and all have their value and contributions to the field, but the best research seems to have elements of all of these.

A designer looks at the interaction tasks necessary for a particular application [12]. Interaction tasks are low-level primitive inputs required from the user, such as entering a text string or choosing a command. For each such task, the designer chooses an appropriate interaction technique. In selecting an interaction device and technique for each task in a human-computer interface, simply making an optimal choice for each task individually may lead to a poor overall design, with too many different or inconsistent types of devices or dialogues. Therefore, it is often desirable to compromise on the individual choices to reach a better overall design.

There may be several different ways of accomplishing the same task. For example, one could use a mouse to select a command by using a pop-up menu, a fixed menu, multiple clicking, circling the desired command, or even writing the name of the command with the mouse. Software might even detect patterns of mouse use in the background, such as repeated "surfing" through menus, to automatically suggest commands or help topics. The latter suggests a shift from the classical view of interaction as direct manipulation where the user is responsible for all actions and decisions, to one which uses background sensing techniques to allow technology to support the user with semi-automatic or implicit actions and services.

Early efforts in human-computer interaction sought to identify elemental tasks that appear repeatedly in human-computer dialogs. Foley, Wallace, and Chan proposed that user interface transactions are composed of the following elemental tasks[12]:

1. Selection: Choosing objects from a set of alternatives
2. Position: Specifying a position within a range. This includes picking a screen coordinate with a pointing device.
3. Orient: Specifying an angle or three-dimensional orientation.
4. Path: Specifying a series of positions and/or orientations over time.
5. Quantify: Specifying an exact numeric value.
6. Text: Entry of symbolic data.

Table 1 provides a list of the potential types of interface transactions that might be needed for communicating computer and human.

Table 1 Types of interface transactions

Type
Selection
Position
Orient
Path
Quantify
Text

While these are commonly occurring tasks in many direct-manipulation interfaces, a problem with this approach is that the level of analysis at which one specifies "elemental" tasks is not well defined.

Treating all tasks as hierarchies of sub-tasks, known as compound tasks, is one way to address this. With appropriate design, and by using technologies and interaction metaphors that parallel the way the user thinks about a task as closely as possible, the designer can phrase together a series of elemental tasks into a single cognitive chunk.

For drawing a circle, a pen is far easier to use. Hence the choice of device influences the level at which the user is required to think about the individual actions that must be performed to achieve a goal.

The six elemental tasks enumerated above may be a complete list of "fundamental" low-level tasks that underlie most interaction with computers, but it could be argued that this list is not complete. Advances in technology will continue to yield new "elemental" inputs. However, these new technologies also may make increasing demands on systems to move from individual samples to synthesis of meaningful structure from the resulting data.

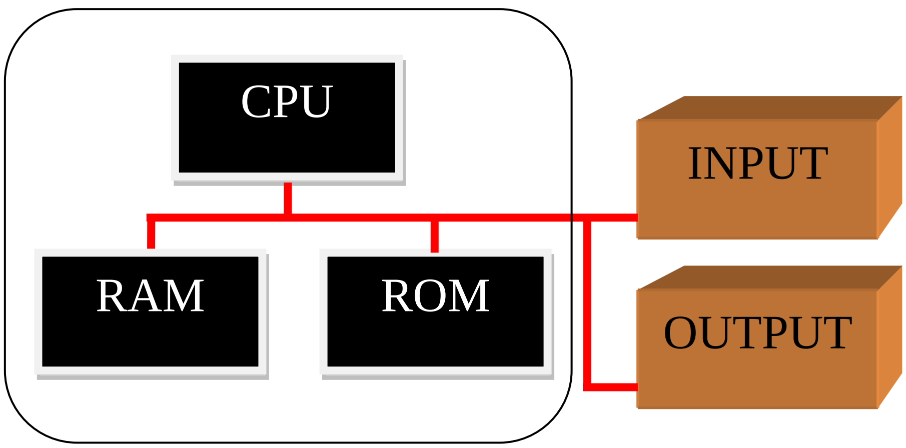

Fig. 1 I/O Device in a Computer Structure.

B. Functions of Input Devices

The breadth of input devices and displays on the market today can be completely bewildering. Fortunately, there are a number of organizing properties and principles which can help to make sense of the design space and performance issues. First, we consider continuous, manually operated pointing devices (as opposed to discrete input mechanisms such as buttons or keyboards, or other devices not operated with the hand).

Physical property sensed. Traditional pointing devices typically sense position, motion, or force. A tablet senses position, a mouse measures motion (i.e. change in position), and an isometric joystick senses force. An isometric joystick is a self-centering force sensing joystick such as the IBM Track Point ("eraser-head") found on many laptops. For a rotary device, the corresponding properties are angle, change in angle, and torque. Position sensing devices are also known as absolute input devices, whereas motion sensing devices are relative input devices. An absolute device can fully support relative motion, since it can calculate changes to position, but a relative device cannot fully support absolute positioning, and in fact can only emulate "position" at all by introducing a cursor on the screen.

Transfer function. A device, in combination with the host operating system, typically modifies its signals using a mathematical transformation that scales the data to provide smooth, efficient, and intuitive operation. An appropriate mapping is a transfer function that matches the physical properties sensed by the input device. Appropriate mappings include force-to-velocity, position to- position, and velocity-to-velocity functions. The user has no feedback of when or to what extent scrolling will accelerate, and the resulting interaction can be hard to learn how to use and difficult to control. If the number of dimensions required by the user's interaction task does not match the number of dimensions provided by the input device, then special handling (e.g. interaction techniques that may require extra buttons, graphical widgets, mode switching, etc) will need to be introduced.

Speed and accuracy. The standard way to characterize pointing device performance employs the Fitts' Law paradigm [13]. Fitts' Law relates the movement time to point at a target, the amplitude of the movement (the distance to the target), and the width of the target (i.e., the precision requirement of the pointing movement). The movement time is proportional to the logarithm of the distance divided by the target width, with constant terms that vary from one device to another. While not emphasized in this chapter, Fitts' Law is the single most important quantitative analysis, testing, and prediction tool available to input research and device evaluation.

Input Device States. To select a single point or region with an input device, users need a way to signal when they are selecting something versus when they are just moving over something to reach a desired target. The need for this fundamental signal of intention is often forgotten by researchers eager to explore new interaction modalities such as empty-handed pointing (e.g. using camera tracking or non-contact proximity sensing of hand position).

Direct vs. indirect control. A mouse is an indirect input device (one must move the mouse to point to a spot on the screen); a touch screen is a direct input device (the display surface is also the input surface). Direct devices raise several unique issues. Designers must consider the possibility of parallax error resulting from a gap between the input and display surfaces, reduced transmission of the screen introduced by a sensing layer, or occlusion of the display by the user's hands.

C. Technology Behavior Based upon TPB

New input device had been introduced into our campus, and computers in education had shown the attention of these certain technology behavior of using new I/O devices. Technology behavior is interested in this study.

The theory of planned behavior (TPB) is a parsimonious model of behavior-specific cognitive determinants [14, 15]. Central to the TPB is the idea that any behavior is determined by behavioral intentions, which are a function of three independent constructs: attitude, subjective norm, and perceived behavioral control. Attitude refers to the evaluative reactions of a person, favorable or unfavorable, towards engaging in the target behavior. The first research hypothesis was set according to previous statement. H_1*: It was hypnotized that there exists significant correlation between intention and attitude toward the new input device.*

Subjective norm reflects individuals' perceived expectation that significant others (e.g., peers) want them to approach or avoid the given behavior (approval or disapproval of the behavior). The second hypothesis was set according to previous statement. H_2*: It was hypnotized that there exists significant correlation between intention and subjective norm of using the new input device.*

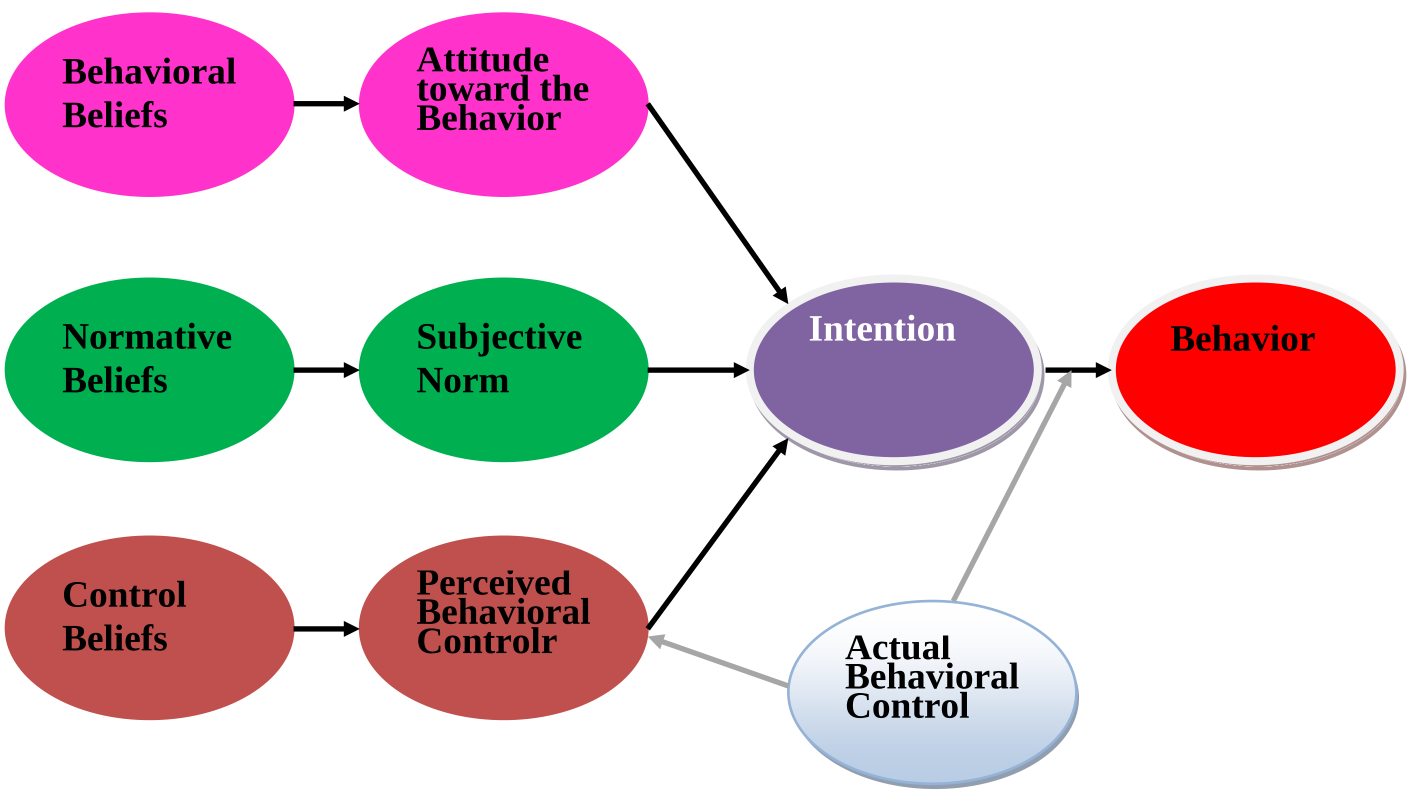

Fig. 2 Cloud Computing Types

In Fig 1, TPB diagram was illustrated. Beliefs in behavior, norm, and control, are the basic components of the whole model. Attitude toward the behavior, subjective norm, and perceived behavioral control are contributing to intention of the certain behavior and the intention contributes behavior. Perceived behavioral control (PBC) was added to the initial theories of reasoned action and pertains to the extent to which a person perceives personal capacities and perceives constraints regarding the target behavior. According to Ajzen [15], beyond its influence on intention, PBC is also held to determine behavior directly. The third hypothesis was set according to previous statement. *H_3:It was hypnotized that there exists significant correlation between intention and perceived behavioral control of using the new input device.*

The TPB has typically been well supported across a wide range of behaviors [16-19]. Studies have also specifically demonstrated its predictive utility for understanding the decision making processes that lead people to violate traffic rules [18]. Although some authors have conceded that individuals could differ in the relative weight placed on attitudes, subjective norms, and PBC [20] and that the weights of the TPB predictors could differ across drivers' behaviors [21, 22], these road traffic studies have limited their investigations to those independent effects postulated 20 years ago [15]. That is, in these studies, attitudes, subjective norms and PBC are considered as independent predictors of road violation behavior.

III. Methodology

The purpose of this study was to assessing the possibility of applying the new input device, Leap Motion, in elementary education. Based upon a reliable behavior predicting model, TPB, an investigation research method was adopted to exploring students' intention in using the Leap Motion device.

A. Participants & Survey Instrument

A survey was developed by researchers to include aspects related to the on-line activity, e-portfolio development, and experience gained to adequately provide insight into participating learners' perceptions. Three items are formulated to assess the theory's major constructs: Attitude, perceived norm, perceived behavioral control, and intention. Seven-point bipolar adjective scales are employed. Twelve items were included. The items were formulated to be exactly compatible with the behavioral criterion and to be self-directed. There are four sub-categories, attitude toward technology behavior, subjective norm, perceived behavior control of using the input device, and intention of using the input device.

A survey procedure was applied to collect data after their operation. Participants were asked to circle the number that best describes their personal opinions.

B. Data Collection & Statistical Analysis

The data collection in this study was done by a TPB based survey instrument. There were two steps of the data collection. In the first step, participants were introduced to the new input device and hand-on operating one by one. Each participant was asked to answer the survey instrument after his/her hand-on device operating procedure.

The survey results were coded according to 12 variables of four sub-categories. In Fig. 2, a conceptual model of verifying technology behavior was drawn. The corrilation statistical test procedure was adopted for verifing all three hypotheses.

For exploring students response, both descriptive analysis and statistical test analysis were used in this study. A correlation test procedure was conducted for verifying those three hypothses.

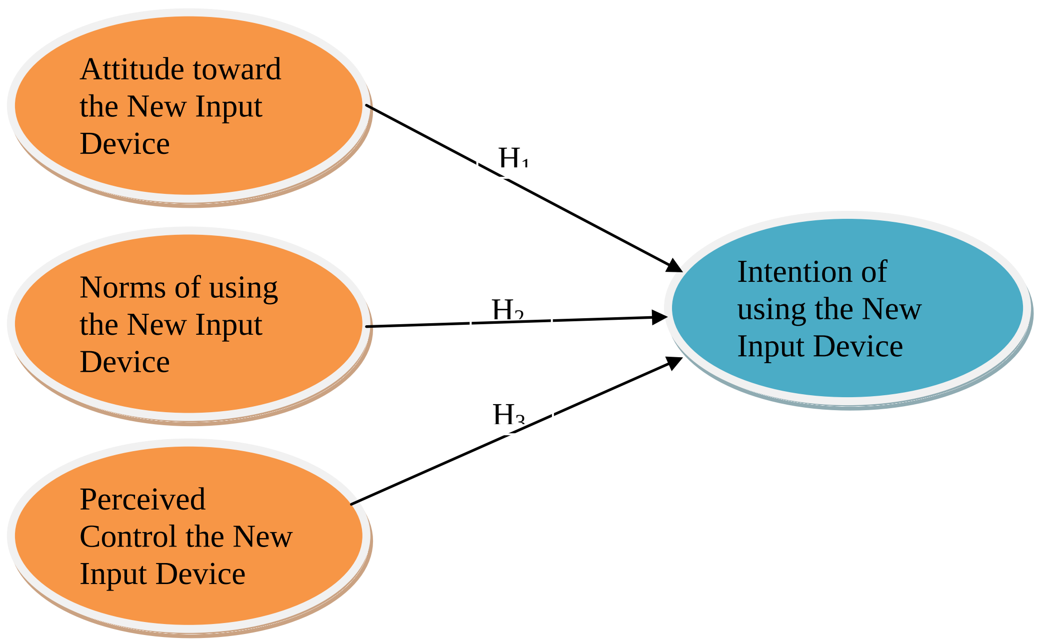

Fig. 3 Conceptual Model of Verifying Technology Behavior

C. Findings

In the following session, the findings of this study would be presented in both descriptive and statistical test. Based on the investigating results, the assessing users' behavior toward the new input device, Leap Motion, would be concluded.

D. Descriptive Analysis

There were twelve items in the survey instrument according to the TPB. The variables were grouped into intention (int1~int3), attitude (at1~at3), subjective norm (sn1~sn3), and perceived behavior control (pbc1~pbc3).

Table 2 Descriptive statistics of questionnair response

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
int1	24	4	7	5.33	1.341
int2	24	4	7	5.21	1.318
int3	24	2	7	5.50	1.532
at1	24	1	7	5.00	1.642
at2	24	4	7	5.58	1.349
at3	24	4	7	5.42	1.248
sn1	24	2	7	5.13	1.484
sn2	24	3	7	4.75	1.359
sn3	24	3	7	4.92	1.316
pbc1	24	4	7	5.37	1.245
pbc2	24	4	7	5.33	1.239
pbc3	24	4	7	5.54	1.179
Valid N	24				

A bi-polar 1~7 scale was applied in the survey. The coding value is from 1 to 7. In Table 2, the number, minimum, maximum, mean, and standard deviation of twelve variables are listed. The number is 24 and the response value is between one and seven. The mean value of variables is around five.

In Table 3, the response result were accumulated in sub-category, intention, attitude, subjective norm, and perceived behavior control. The number, minimum, maximum, mean, and standard deviation of four sub-categories are listed. The number is 24 and the response value is between 10 and 21. The mean value of variables is around 15 and 16.

Table 3 Sub-category Descriptive statistics of questionnair response

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Intention_c	24	11.00	21.00	16.0417	3.81620
Attitude_d	24	11.00	21.00	16.0000	3.50155
norm_e	24	10.00	21.00	14.7917	3.41326
control_g	24	12.00	21.00	16.2500	3.47976
Valid N (listwise)	24				

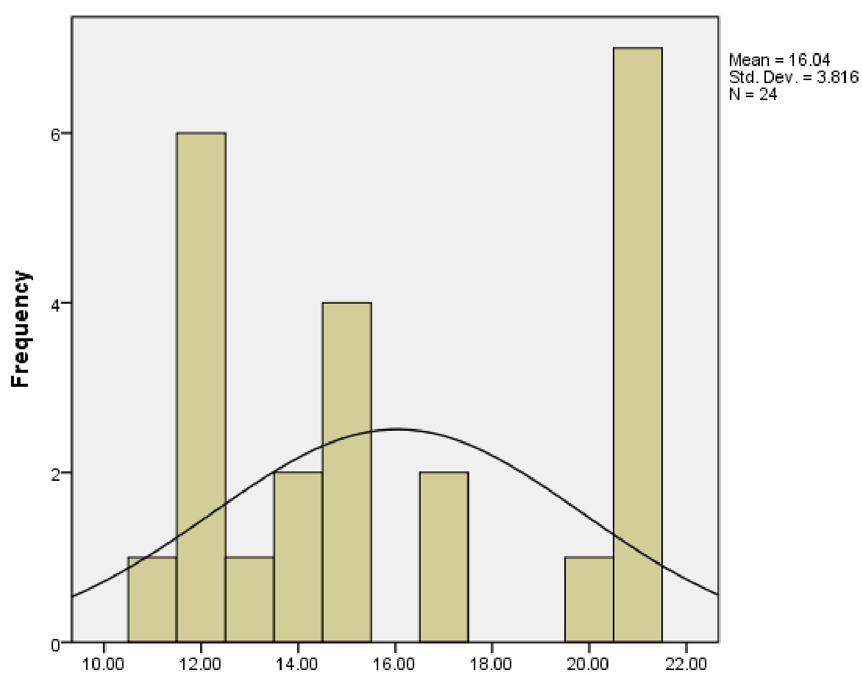

Fig. 4 The historgram of variable intention

For exploring the response of item intention, a frequency distribution was made in Table 4. The value 21 shows the highest frequency with 29%.

Table 4 Frequency distribution of variable intention

Intention					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	11.00	1	4.2	4.2	4.2
	12.00	6	25.0	25.0	29.2
	13.00	1	4.2	4.2	33.3
	14.00	2	8.3	8.3	41.7
	15.00	4	16.7	16.7	58.3
	17.00	2	8.3	8.3	66.7
	20.00	1	4.2	4.2	70.8
	21.00	7	29.2	29.2	100.0
	Total	24	100.0	100.0	

In Fig.4, the histogram of variable intention was illustrated. The distribution has highest on right side value 21 and second high on the left side value 12. The third high value 15 is in the middle.

For exploring the response of attitude toward using the leap motion, a frequency distribution was made in Table 5. The value 21 shows the highest frequency with 20.8%.

Table 5 Frequency distribution of variable attitude

Attitude					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	11.00	1	4.2	4.2	4.2
	12.00	4	16.7	16.7	20.8
	13.00	4	16.7	16.7	37.5
	15.00	3	12.5	12.5	50.0
	16.00	2	8.3	8.3	58.3
	17.00	2	8.3	8.3	66.7
	19.00	3	12.5	12.5	79.2
	21.00	5	20.8	20.8	100.0
	Total	24	100.0	100.0	

In Fig.5, the histogram of attitude toward using the new input device of leap motion was illustrated. The distribution has highest on right side value 21 and second high on the left side value 12 and 13.

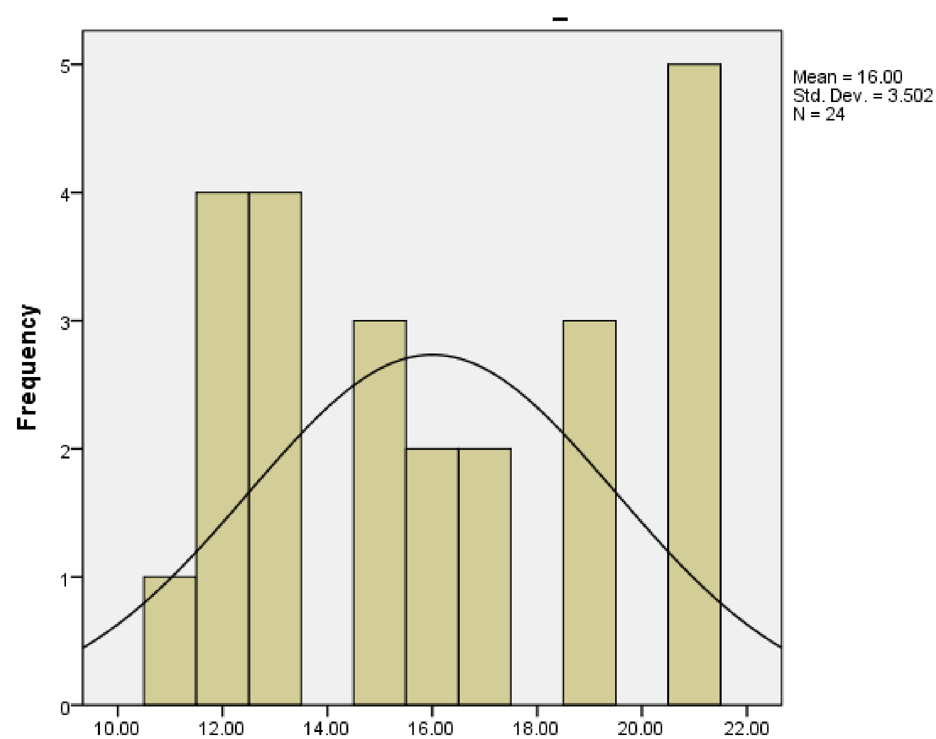

Fig. 5 Histogram of variable Attitude

For exploring the response of subjective norm on using the leap motion, a frequency distribution was made in Table 6. The value 12 shows the highest frequency with 33.3%.

In Fig.6, the histogram of attitude toward using the new input device of leap motion was illustrated. The distribution has highest on left side value 12 and second high on the right side value 17.

Table 6 Frequency distribution of subjective norm

Subjective norm					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10.00	1	4.2	4.2	4.2
	11.00	1	4.2	4.2	8.3
	12.00	8	33.3	33.3	41.7
	13.00	1	4.2	4.2	45.8
	14.00	3	12.5	12.5	58.3
	15.00	1	4.2	4.2	62.5
	17.00	4	16.7	16.7	79.2
	18.00	1	4.2	4.2	83.3
	19.00	1	4.2	4.2	87.5
	21.00	3	12.5	12.5	100.0
	Total	24	100.0	100.0	

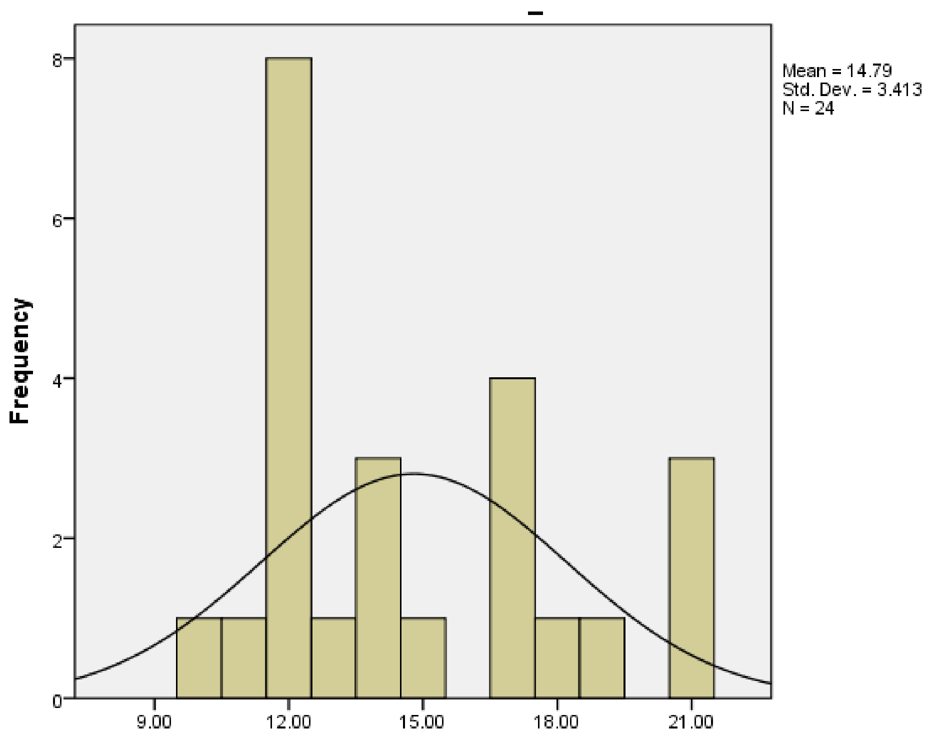

Fig. 6 Histogram of variable Subjective Norm

For exploring the response of perceived behavior control on using the leap motion, a frequency distribution was made in Table 7. The value 21 shows the highest frequency with 25.0%.

Table 7 Frequency distribution of variable perceived behavior control

Perceived Behavior Control					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	12.00	4	16.7	16.7	16.7
	13.00	2	8.3	8.3	25.0
	14.00	5	20.8	20.8	45.8
	15.00	2	8.3	8.3	54.2
	16.00	1	4.2	4.2	58.3
	18.00	2	8.3	8.3	66.7
	19.00	2	8.3	8.3	75.0
	21.00	6	25.0	25.0	100.0
	Total	24	100.0	100.0	

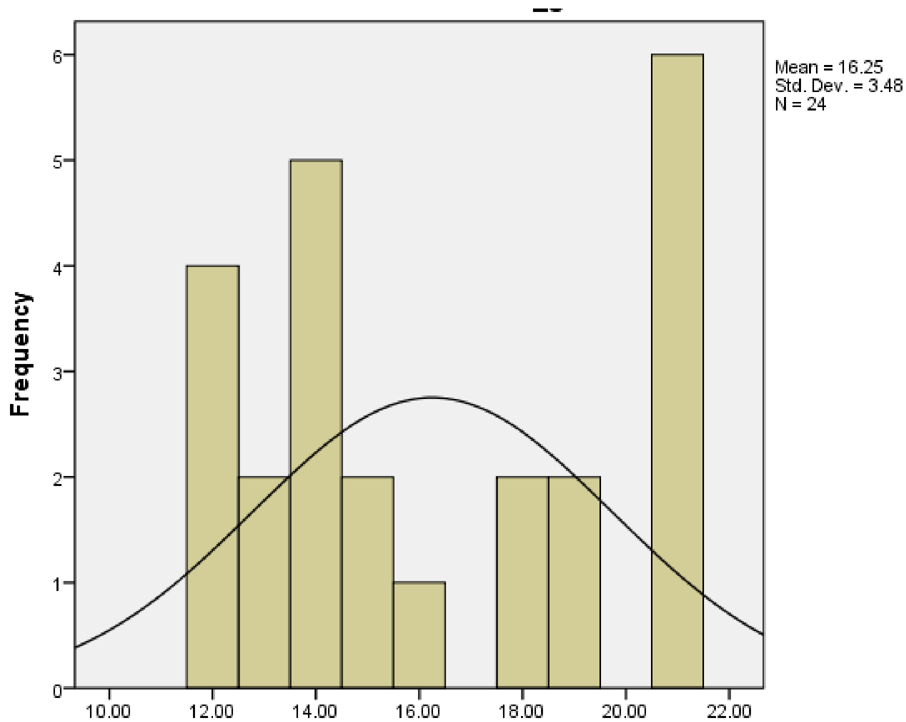

Fig. 7 The histogram of variable PBC

In Fig.7, the histogram of perceived behaviour control of using the new input device of leap motion was illustrated. The distribution has highest on right side value 21 and second high on the left side value 14.

E.Results of Statistical Tests

Based upon the theory of planned behavior, the attitude toward using the new input device, leap motion, could be significantly contribute to form the intention of using the leap motion. The hypothesis was set as following and was tested.

H_1: It was hypnotized that there exists significant correlation between intention and attitude toward the new input device.

The result is listed in Table 8. The Pearson correlation between intention and attitude is 0.879 with significant value of 0.000.

Based upon the theory of planned behavior, the subjective norm of using the new input device, leap motion, could be significantly contribute to form the intention of using the leap motion. The hypothesis was set as following and was tested. The result is listed in Table 8.

H2: It was hypnotized that there exists significant correlation between intention and subjective norm of using the new input device

The Pearson correlation between intention and subjective norm is 0.595 with significant value of 0.002.

Based upon the theory of planned behavior, the perceived behavior control of using the new input device, leap motion, could be significantly contribute to form the intention of using the leap motion. The hypothesis was set as following and was tested. The result is listed in Table 8.

H3:It was hypnotized that there exists significant correlation between intention and perceived behavioral control of using the new input device.

The Pearson correlation between intention and subjective norm is 0.929 with significant value of 0.000.

Table 8 Correlations between intention and three contributing variables

Correlations				
		Attitude	norm	control
Intention	Pearson Correlation	.879**	.595**	.929**
	Sig. (2tailed)	.000	.002	.000
	N	24	24	24

IV. CONCLUSION

The theory of planned behavior (TPB) is a parsimonious model of behavior-specific cognitive determinants Central to the TPB is the idea that any behavior is determined by behavioral intentions, which are a function of three independent constructs: attitude, subjective norm, and perceived behavioral control.

Attitude refers to the evaluative reactions of a person, favorable or unfavorable, towards engaging in the target behavior. Subjective norm reflects individuals' perceived expectation that significant others (e.g., peers) want them to approach or avoid the given behavior (approval or disapproval of the behavior). Perceived behavioral control (PBC) was added to the initial theories of reasoned action and pertains to the extent to which a person perceives personal capacities and perceives constraints regarding the target behavior.

According to the finding of this study, the new input device Leap Motion owns significant potential in been used in elementary education. According to the attitude toward using Leap Motion, elementary students' intention could be the main factor for the users to conduct their behavior.

According to the subjective norm of using the new input device, users applying behavior could be predicted with significantly confidence. Based upon the result of perceived behavior control investigation, it is believed that the behavior of using the Leap Motion device is with significantly high possibility for the elementary students.

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