Selection of Touch Gestures for Children's Applications: Repeated Experiment to Increase Reliability

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Abstract— **This paper discusses the selection of touch gestures for children's applications. This research investigates the gestures that children aged between 2 to 4 years old can manage on the iPad device. Two experiments were conducted for this research. The first experiment was carried out in United Kingdom. The second experiment was carried out in Malaysia. The two similar experiments were carried out to increase the reliability and refine the result. This study shows that children aged 4 years have no problem using the 7 common gestures found in iPad applications. Some children aged 3 years have problem with two of the gestures. A high percentage of children aged 2 years struggled with the free rotate, drag & drop, pinch and spread gestures. This paper also discusses the Additional Criteria for the use of Gestures, Interface Design Components and Research on Children using iPad and Applications.**

Keywords— Children; Gesture; Applications (Apps)

I. INTRODUCTION

Gestures are defined by [1] as a powerful feature of human expression, either alone or as a means for augmenting spoken language. This paper is focusing on our experiment in Malaysia which is the latest phase of our study which started in 2012. In this research four education and games category apps for the iPad were selected from the Apple store and seven gestures were chosen for study as used in our previous research for young children aged 2 to 4 years in United Kingdom [2]. This paper reports the result of an experiment carried out on children in Malaysia and highlights the differences and similarities compared to the previous similar experiment carried out in the United Kingdom.

This paper is divided into the following sections: Literature Review, Experiment Set Up, Results & Discussion, Conclusions.

II. LITERATURE REVIEW

Play is not only an enjoyable and spontaneous activity of young children but it also contributes significantly to children's psychological development [3]. Children are always being curious and want to explore new things in their life. It is this curiosity that makes the touch screen technology so popular. With just a touch of a finger, children can interact with a smart phone or tablet [4]. When teachers or parents use technology that children are comfortable with, they may be encouraged to learn through playing.

The result from the research which compares the use of tablet internationally in 2012 [5] shows that the use of tablets is not high in many countries with 18% in Egypt and Chile, followed by 7% in Indonesia and 5 to 7% in Japan and India. The use of tablets by children may be hindered by the high purchase price. Wider use of tablet is expected due to the price drop every year. The research [5] compares the use of tablet in general but not specifically in school. The use of iPad tablet in large numbers in Alberta classrooms was recorded in the Alberta Summary Report [6] with 147 participants, representing 25 school authorities. They noticed that the use of iPads has increased student and teacher engagement, improved the capacity to meet a wide variety of learning needs and provided more ways for students to demonstrate their understanding. Even though tablets, especially iPad, are not widely used among children generally [5], they are used in classrooms like Alberta schools where government funding was available.

The study [7] is about the cultural and economic differences on the use of mobile phones and computers by children in general and was done with native Dutch and Immigrant children aged 4 to 7 years. There are no significant differences found between the attitudes of Dutch and immigrant children in using computers. The children from a lower socio-economic neighborhood had more positive attitudes towards computers and used computers slightly more often than middle class children [7]. The findings [7] showed that culture does not influence children in using mobile phone and computers.

Research is necessary to understand and enable the real benefits of these increasingly popular technologies [8]. Providing an experiment on how children use gesture has great potential to provide design guidance and positively influence children's digital experiences with these new forms of technology [4, 8].

The study by [9] of using iPad as a learning tool for children between 8 and 12 years old and their teachers related to the design activities and the use of iPad application. The children evaluated the use of iPad as truly successful.

However the children's criteria of success were how fun and enjoyable it was to use the iPad, and the ability to work in teams and try something new. Meanwhile their teachers found that the use of iPad did not improve the children's learning outcome [9].

According to [10] the children felt that the technology supported them appropriately when it offered them control, no matter how small, of their physical interactions. The developing of physical coordination skills and physical sizes of young children place restrictions on using technology and this is the challenge for designers when developing physical interfaces for young children.

Like the Alberta Schools which used iPad in school [6], the study by Michael Cohen Group's also discussed children's ability in using iPad in general. However, the study did not focus on the use of touch screen gestures in detail [11].

Recent studies that related to our study are more on the use of touch screen and gestures in general by young children [2]. The most closely related study was done by Sesame Street. The creators of Sesame Street discuss in the short section on gestures that they have identified the most and the least intuitive gestures for preschool aged children. They have found tap, draw/move finger, swipe, drag and slide to be the most intuitive gestures. Pinch, tilt/shake, multi-touch, flick/fling and double tap are the least intuitive gestures [12]. However they do not draw any distinction among children by age.

To the best of our knowledge, no research has investigated and compared the gestures among children by age.

This paper is focusing on our experiment in Malaysia which is the latest phase of our study which started in 2012. The first phase of this study was to identify the common gestures used in children's applications [4], select the appropriate applications (apps) for the experiment and carry out the pilot study [13] and experiment in the United Kingdom [2].

The common gestures used in children's applications were found to be Tap, Drag/Slide, Free Rotate, Drag & Drop, Pinch, Spread and Flick. These gestures were found in 100 children's applications from the Apple store [4].

Following on from the pilot study which investigated children aged 2 to 12 years (3 children for each group) in using 7 gestures in United Kingdom, we conducted an experiment with 37 children aged 2 to 4 years in the United Kingdom. Seven types of gestures were chosen on iPad applications. The results from our study in United Kingdom showed that all gestures can be used by children at aged 4 years and children aged 2 to 3 years have problems using certain gestures. Therefore, this study will use the same experiment design for aged 2 to 4 years with the same seven gestures with children of a different culture in Malaysia in order to increase reliability and allow us to refine the result.

III. EXPERIMENT SET UP

We use the same experiment set up as our previous experiment in United Kingdom. This repeated experiment is to increase reliability and allow us to refine the result. We believe that the repetition of experiment reduces the possibility of errors and also verifies the accuracy of the previous findings.

In terms of experiment methodology, according to [14] researching with children is different from researching with adults. The researcher has to establish a friendly relationship with children. The researcher has to interact with them in the most trusted way possible without having any explicit authority role. Therefore more time is needed to interact with children and gain their trust. In this experiment we have spent more time with each individual child in the experiment Malaysia's experiment compared with the experiment in the United Kingdom.

The four selected applications are: Montessori Crosswords (English versions), AlphaBaby Free (English versions), Toca Hair Salon and Toca Kitchen Monsters.

An interface should use language and concepts that the user is familiar with [15]. The method of selection of the 4 applications in our research included a check that the applications used language and concepts that children are familiar with. The Malay language is the first language for children in Malaysia but they also learn English as a second language from preschool.

Toca Hair Salon and Toca Kitchen Monsters did not use language as a medium for user interaction. Both apps provide a gestural interface for young children. Hair Salon provides gestures for combing, cutting, spraying, and coloring hair. Toca Kitchen Monsters used the kitchen theme and allows the children to use gestures to choose food, cook and feed the monsters.

The Alpha Baby application provides young children with a gestural interface for learning basic alphabet, numbers and shape using the English language. The Montessori Crosswords app maybe the most challenging one for young children to interact with because they have to drag letters to form a word based on images showed on the screen. For young children who do not know how to read, the teacher and researcher will show them the correct letters they have to choose in order for them to perform the gestures. The teacher and researcher have to bear in mind that the experiment is to evaluate the children's capability to use different gestures and not their spelling.

Forty children from National Children Development Research Centre (NCDRC), Sultan Idris Education University, Malaysia participated in this study. The children were aged:

1) 2 years (10 children)
2) 3 years (14 children)
3) 4 years (16 children)

The children used an iPad one at a time in a comfortable environment. The researcher together with the teacher guided the child to play with each application. Based on past experience, more time was given to children aged 2 and 3 years to play and familiarize themselves with the applications and gestures. The children were given the opportunity to use the same gesture 3 to 5 times before their gestures were being

recorded. A digital video camera was used to record the gestures made by each child.

IV. RESULTS AND DISCUSSION

This section is divided into the following sub-sections: Gestures that can be used by Children, Additional Criteria for the use of Gestures, Interface Design Components and Research on Children using iPad and Applications.

A. Gestures that can be used by Children

Seven common gestures were selected for this experiment: tap, drag/slide, free rotate, drag & drop, pinch, spread and flick. Table I summarizes the results of the analyzed video recorded during experiment with 40 children aged 2 to 4 years, in Malaysia and 37 children aged 2 to 4 years in United Kingdom .

TABLE I. GESTURES THAT CAN BE USED BY CHILDREN AGED 2 TO 4 YEARS

Gestures	Age 2		Age 3		Age 4	
	M	UK	M	UK	M	UK
Tap	100%	100%	100%	100%	All 100%	
Drag/Slide	100%	100%	100%	100%		
Free Rotate	40%	55%	100%	91%		
Drag & Drop	30%	36%	100%	100%		
Pinch	30%	55%	71%	82%		
Spread	10%	11%	64%	36%		
Flick	80%	36%	100%	73%		

M=Malaysia UK =United Kingdom

The table shows the list of gestures in the first column and the following columns show the percentages of children aged 2 to 3 years who can use the gestures. We exclude the details result for children aged 4 years old in Table I because all of them could use all 7 gestures successfully in both the Malaysia and United Kingdom experiments.

This research consistently considers that a percentage lower than 70% indicates that the children are struggling in using gestures and a higher percentage indicates they are successful in using the gestures.

Table I shows that all children from aged 2 to 4 years can use the tap and drag/slide gesture. The gestures are easy and natural as this is what children see and do in their real life. The research [12] also found that tap is the most intuitive and foundational touch interaction for children.

The free rotate gesture requires the children to twist their fingers. It is shown that only 40% children from aged 2 years from Malaysia and 55% from United Kingdom can use the free rotate gesture. This indicates that children aged 2 years old are struggling to execute the free rotate gesture. The observation shows that children aged 2 years did not have the capability to twist their fingers easily such as rotating a letter in the Alpha Baby application. All children aged 3 and 4 years

can use free rotate gestures. This study confirms that children aged 3 and 4 years have no problem in using this gesture.

The drag & drop gesture requires the children to press and move their finger without losing contact with the surface. Only 30% of children aged 2 years from Malaysia and 36% from United Kingdom can use drag & drop gesture. This indicates that children aged 2 years old are struggling to execute the drag & drop gesture. The reason may be either that they do not understand how to do the drag & drop gesture or their motor skill is not yet fully developed or both. The children were required to use the drag and drop gesture in the Toca Kitchen Monsters, Toca Hair Salon and Montessori Crossword applications. All children aged 3 and 4 years were successful in using the drag & drop gesture.

The pinch gesture requires the children to use two fingers and bring them closer on the surface. The result also shows that only 30% of the children aged 2 years from Malaysia and 55% from United Kingdom can use the pinch gesture. This indicates that children aged 2 years are also struggling to execute the pinch gesture. For example children aged 2 years were struggling to pinch the shape to make it smaller in size in the Alpha Baby application. Perhaps they lack the capability to perform pinch gesture (motor skill) or do not understand how to do the gesture (cognitive level). Meanwhile, 71% children from Malaysia and 82% from United Kingdom aged 3 years and all children aged 4 years can use the pinch gesture.

The spread gesture requires the children to touch the surface with two or more fingers and move them apart. With the spread gesture, 10% of the children aged 2 years from Malaysia and 11% from United Kingdom can use it. This indicates that children aged 2 are struggling to execute the spread gesture. Like free rotate, drag & drop and pinch, it is assumed the reason for the struggle maybe either that they do not understand how to do the spread gesture or their motor skill is not yet fully developed or both. 64% of the children aged 3 years from Malaysia and 36% from United Kingdom can use the spread gesture. This also indicates that children aged 3 years are struggling using spread gesture even though the table shows the percentage were increased. The increased percentage maybe because they were given an opportunity to use every gesture 3 to 5 times before the researcher record their fingers movement.

The flick gesture requires the children to use their finger to brush the surface. With the flick gesture, surprisingly 80% of the children aged 2 years from Malaysia can use it even though only 36% children aged 2 years from United Kingdom can use the gesture. The increased percentage maybe because they were given an opportunity to use every gesture 3 to 5 times before the researcher recorded their finger movement. This may suggest that 2 years old children could learn some of the gestures with practice. This indicates that Malay children aged 2 years have no problem with flick gestures as well as children aged 3 and 4 years.

The results in Table I show that Malaysia's experiment seem to be consistent with the results of the experiment in the United Kingdom except for a surprising percentage increase in the flick gesture for 2 year old and the spread gesture for 3 year old children.

These results also confirm the full capabilities of children aged 4 years in using all seven gestures. Meanwhile children aged 3 years also struggling using spread gesture. Attention should be given to children aged 2 years old who are struggling to use more than half of the seven gestures. Therefore developers should be careful with the application design for children aged 2 and 3 years. The selection of gestures needs to be appropriate to the children's age for application design and this experiment shows a strong relationship between age and the gestures that can be used.

B. Additional Criteria for the use of Gesture

Four additional criteria for the use of gestures are identified in the previous UK study.

  1) Unique gesture or 'one gesture - one task',
  2) simultaneous gestures,
  3) consistent gesture and
  4) natural gesture.

Unique gesture is one gesture implemented to achieve any given task on a particular component. Simultaneous gestures can refer to the set of all gestures used in all tasks on all components or the ability to apply a gesture to more than one component at once. The requirement for consistency in gestures is the use similar gesture for a similar task on other components on other screens. The natural gesture is where the use of the gesture is consistent with its use in the real world [2]. The observation and the analysis of the records for the Malaysian experiments confirm the conclusions about the additional criteria previously as previously identified.

Children's applications come with components which are touchable such as shapes, letters, numbers or objects. As in our previous experiment, our observation shows that simultaneous gestures have no meaning to young children aged two and three years. 90% of the children aged 2 to 3 years only use one unique gesture for each task even though they are taught to use other gestures by the researcher or their teacher. For example the Alpha Baby application was designed with 6 gestures on the same screen. Children could use tap to allow the component (number/alphabet/shape) to appear on the screen and use other gestures such as drag/slide, pinch, spread, flick and free rotate to move, resize, animate and rotate the components. Our observation shows that the children keep tapping a letter or digit on Alpha Baby application instead of using other gestures. Therefore the designer could consider using just the tap gesture or another unique gesture for Alpha Baby application.

The inconsistent gestures make children confused. For example, 80% children aged 2 to 4 years in Malaysia and the same percentage of children aged 2 to 4 years in United Kingdom were using the drag/slide or tap gesture even though they have to do drag & drop gesture in the final screen in Toca Hair Salon. This is because every screen in Toca hair Salon used the same gesture except the final screen. The children looked confused at the beginning until the researcher asked them to use the correct gesture. The children are able to use the application smoothly if the application's designers use consistent gestures for the whole application.

Our observation in Malaysia's experiment also shows that 50% of children always use natural gestures at the beginning of their interaction with applications. For example the children try to pick the food from refrigerator (using all fingers like pinch gesture) in Toca Kitchen Monsters application instead of dragging and dropping the food into the monsters mouth. The designer may use pinch gesture instead of drag and drop to select food from the refrigerator for the Toca Kitchen Monsters application.

Our previous research finding also shows that young children aged 2 to 4 years old need a natural interface design for touch screen application. Little children playing or using the application on the touch screen instinctively followed the way they have done it in the real world such as picking object, feeding pet and combing hair by using all fingers like the pinch gesture [2].

C. Interface Design Components

This section discusses the interface design components which are touchable, e.g. a shape, a letter, a number or any object in a children's application [2].

The observation for the Malaysian experiment is also consistent with the previous experiment that too many components for every page will keep children busy sorting the components (numbers/letters/objects) rather than answering the question given on that page and the children also found it difficult and got confused when using gestures on crowded interface design such as in the Montessori Crossword and the Alpha Baby application. 50% of children aged 3 to 4 years were busy sorting the components meanwhile 100% children aged 2 years were only tapping and staring at the components on the screen. The application designer should consider simple design such as one component for each screen, consistency of the components and their arrangement throughout the whole application such as using one type of component for each screen and place it in the middle of the screen.

40% of the children aged 3 to 4 years also relate the image or item they see on the application to what they usually see in the real world. For example the children try to rotate the water tap to wash the cartoon character's hair in the Toca Hair Salon application instead of using a tap gesture. The children also try to use inactive images such as butter together with other food in Toca Kitchen Monsters. The selection of image and gesture must be consistent with its use in the real world as mentioned in Section IV-B because children will use natural gestures associated with the image.

Observation also shows that 20% of the children aged 2 years old did not want to play with certain cartoon characters in Toca Kitchen Monsters and Toca Hair Salon when the researcher showed the applications. They kept crying and ignored the application throughout the experiment. Therefore, before using any image, especially a cartoon character, the application's designers have to test it on young children to ensure the character does not scare them.

When designing an interface, a designer is encouraged to reduce the number of components for each page, select appropriate images/characters for young children and arrange

the components in a consistent and simple way for the whole applications.

D. Research on Children using iPad and Applications

Observation also shows that children aged 2 years old need more time to familiarize themselves with the applications. They also need more time to interact in a friendly mode with the researcher who was an outsider to them. Male children aged 2 years old are friendlier than female but in terms of understanding and following the instructions, the female children are better. Overall observation shows children aged 2 years old were more likely to feel uncomfortable, become distracted or cry. For much of the time the teachers and researchers had to hold their hand and show them how to use the gestures correctly. They were also uncontrollable and used their fingers on the screen without any purpose or understanding what they were doing.

Children aged 3 years old were also eager to use the iPad and the applications especially the male children. The researcher had to guide them to use all seven gestures but they required less time to understand how to use the gestures and interact with the application in comparison to children aged 2 years old. Children aged 3 years old were also easily influenced by their friends. They were eager to play with the application when they saw their friends interacting with it.

Children aged 4 years old are highly motivated or eager to explore all the applications. They also understand how to use the gestures and applications easily. This observation confirmed that children aged 4 years have no problems using all the seven gestures and interacting with all four applications. Therefore the designer may use all seven gestures for children aged 4 years.

Overall observation shows that the children's favourite application is the Toca Kitchen Monsters and more than half of the children did not like to play or interact with Montessori Alphabet. The Toca Kitchen Monsters application is popular among children and this may be because of the use of consistent gesture (drag & drop), and because feeding the monsters is related to what the children do in the real world (children eat or their mother feeds them every day).

V. CONCLUSION

An overall observation indicates that the children's age, components criteria and interface design components influence the children's capability of using gestures in every screen.

The results of this experiment are consistent with our previous experiment which was done in United Kingdom except for the flick gesture for children aged 2 years old and the spread gesture for children aged 3 years as shown in Table II.

TABLE II. GESTURES THAT CAN BE USED BY YOUNG CHILDREN AGED 2 TO 4 YEARS

Malaysia		
Age 2	**Age 3**	**Age 4**
Tap Drag/Slide Flick	Tap Drag/Slide Drag & Drop Free Rotate Pinch Flick	Tap Drag/Slide Drag & Drop Free Rotate Pinch Flick Spread

Children aged 2 years old successfully used the flick gesture and the percentage of children aged 3 years old also increased in using the spread gesture in Malaysia's experiment. This may be because more time was allocated for them to play with the gesture and application compared to our experiment in United Kingdom. Our observation shows that there are no significant differences in the understanding and use of gestures between the children in Malaysia and United Kingdom arising from the differences in culture. The result for this repeated experiment confirmed that gestures that can be used by children aged 2 to 4 years old. This result suggest that application designer can use tap, drag/slide and flick gestures in children's applications aged 2 years and add drag & drop gesture for children aged 3 years and all seven gestures for children aged 4 years and above.

The application designer also needs to consider the children's response to other gestures criteria, interface design components and how the children interact with applications and iPad. The way that an application designer chooses and arranges the gestures must be appropriate. The application designer should use a unique gesture for a given task, consistent gestures across different screens and natural gestures for the whole application. When designing an interface, a designer is encouraged to reduce the number of components for each page, select appropriate images/characters for young children and arrange the components in a consistent and simple way for the whole applications.

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