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Perception of Parents towards Fun Puzzle Games in Helping Mild Autistic Children Improve Their Computational Thinking Skills

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Abstract: The COVID-19 pandemic has caused much stress. Autistic children and their parents/guardians are not exempted. The question is how to engage the autistic children virtually. There are many online games, which can address this problem and they are very exemplary. In our small study, we aim to balance education and fun, so that learning is not too serious. We also aim to improve autistic children's computational thinking skills and enable asset/content reuse. We have reduced the degree of structure, with familiarity in contexts as affordance in four minigames: categorizing puzzle, matching-sorting puzzle, picture puzzle and outdoor puzzle. Through computational practice, we hope that children will be able to recognize patterns, improve concepts and perspectives, and perform better. We also hope to encourage asset reuse via algorithmic changes. Findings are encouraging, indicating that parents/guardians are positive towards the games' usefulness and ease of use. Of special note is their preference for the learning of vocabulary and development of imagination, above matching and categorizing.

Keywords: Mild autistic children, computational thinking skills, perception, parents/guardians

1. Introduction

The recent COVID-19 pandemic has caused schools in Malaysia to close to prevent the spread of the virus. This has caused children to do most of their learning at home with the aid of their family members, instead of their educators. In the home, most games for children with autism usually focus more on educating children, or on helping them to improve basic skills to cope with their difficulties. Sometimes, the "fun" element is lacking.

Every child with mild autism should have the opportunity to play games for the sake of fun, just like other children around their age. This project thus hopes to address the need to enable children to have fun, without the need to go outside the home or school, and yet be able to interact with a number of people. We would thus, like to investigate how to incorporate fun, education, and design patterns, to help mild Autistic Spectrum Disorder (ASD) children improve their basic skills and computational thinking skills.

The benefits of varied and repeated practice are supported by Emihovich (2017) and Lee and Ling's (2020) studies. Emihovich's (2017) study compares students' performance after playing *World of Warcraft* (a roleplaying strategy video game) with *CogniFit* (a brain training video game). Emihovich (2017) finds better improved problem-solving skills for role-playing games in the Tower of Hanoi and PISA post-test results. Hence, more complex learning environments are not constraints to problem-solving if designed well.

Lee and Ling (2020) simulate Emihovich's (2017) study but replace the two games with the fast-paced video game *Mario Kart Tour* and the role-playing game *Idle Supermarket Tycoon* and test the effects on speed performance when playing the *Tower of Hanoi.* Consistent with Emihovich's (2017) findings, students who play *Idle Supermarket Tycoon* outperform those who play *Mario Kart Tour*. In the pre-post-tests, mean completion speed for the former is 73.60-49.78 = 23.82 whereas for the latter, 49.67-39.33 = 10.34. The improvement between pre-post-test scores for the former is much greater. Hence, if games are mapped to the type of skills one wishes to improve, with similarity in demands of the tasks, analogical transfer may be more likely to occur and the learning curve lessens.

1.1 Problems and Objectives

Consistent with Spiro, Feltovich, Jacobson, & Coulson's (1991) Cognitive Flexibility theory (CFT), most games for ASD children provide a combination of structured and less structured problems (examples are presented in the related work section). Brennan, and Resnick's (2012) computational concepts, practice and perspectives correspond with CFT. Furthermore, Lee's (2008) study into balancing of fun, education and entertainment elements with design patterns, has mapped Merrill's First Principles of Instruction (2002) as pedagogical patterns, to Dunlap, Sobel and Sands' (2007) student-to-content interaction patterns and Bloom's (Anderson & Krathwohl, 2001) revised taxonomy. However, it is a framework, which hitherto, is not applied as is, or to autistic children.

Our focus is on identifying parents' perceptions prior to possible deployment with the children with ASD. We choose to focus on structured part-whole relations, which students are used to, and progress to explore less structured part-whole relations in diverse contexts. We hypothesize that part-whole relations afforded by familiar and authentic/relevant contexts, with opportunities to find hidden functions and to fix/create, (just like normal children), can motivate play and increase fun.

Our research questions are thus:

a) Will parents/guardians like less structured problems, which are afforded by familiar contexts?
b) Will parents/guardians like authentic problem-solving, involving in-house and out-of-the-house objects, e.g., tidying up after play, exploring hidden functions in the house and fixing/creating something outside the house?

2. Related Work

This section reviews the design of several popular and successful games developed for children with ASD. It includes comparison between the reviewed game application and the project itself; to provide insights on what the project should have to create a game, which would answer the research questions.

2.1 AutiSpark: Games for Kids with Autism

AutiSpark: Games for Kids with Autism (AutiSpark, 2020) is an educational app that uses 2 dimensional (2D) minigames to teach basic concepts for children with ASD. The app contains several categories that are related to fundamental concepts/skills that children with ASD have trouble with. The categories that are available in this game are coloring, flash cards, memory, counting, and tracing, matching, sorting, learn new words, letters and numbers, receptive language, puzzles, copy the patterns, jigsaw puzzles. Sample screenshots are presented in Figures 1a, b.

2.2 Autastisco

Autastico is a free-to-play educational game with simple minigames, suitable for children with ASD. The app consists of 6 playable games: *Draw Shapes!, The Emotions, Create Your Avatar, The Numbers, The Colors and Solve Puzzles* (Autastico, 2016). Sample screenshots are presented in Figures 2a, b.

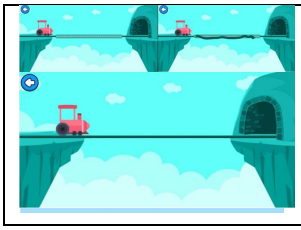

Figure 1a. *Trace the line*

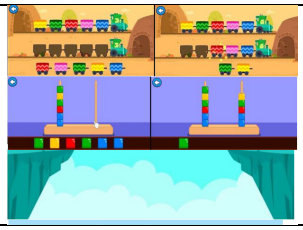

Figure 1b. *Copy the patterns*

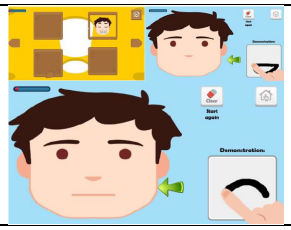

Figure 2a. *The Emotions*

Figure 2b. *The Colors*

2.3 Table of Comparison

We next identify the key aspects for our study in Table 1 below.

Table 1. *Comparative Components*

Problem-solving skill	**Approach**								
	Listening			**Reading**			**Speaking**		
	AutiSpark	Autastico	This study	AutiSpark	Autastico	Project	AutiSpark	Autastico	This study
Calculate numbers					x		x		
Categorize	x			x			x		
Match/Shapes			x	x		x	x		x
Puzzles	x			x			x		
Sort/complete puzzles	x		x	x			x		
Match/complete puzzles	x	x	x	x			x		
Connecting Pipes puzzles	imagination/multiple alternatives								

2.4 Prior literature on autism

Children like fun and theorize naturally (Lee & Wong, 2014). Lehigh University's Graceland Autism (2016) initiative, engages children and teenagers with several mobile applications, e.g., a grocery shopping simulator, shelf-stocking simulator, and a conversation simulator. These emulate and prepare them for real-life challenges. The Olga Tennison Autism Research Centre (2019) uses video games to promote social attention, interaction and communication skills. Laurie, Warreyn, Uriarte, Boonen, and Fletcher-Watson's (2019) study suggests that technologies which aim at therapy, must engage users; necessitating much design considerations. Autism Associations and authors such as Weigie (2014), however, warn against play addiction. Hence, parental supervision is preferred.

2.5 Derivation of key aspects of our proposed game

First, we will focus on relevance to real-life challenges, similar to Graceland's. Second, we will balance educational and fun elements. Third, the educational level in this game will be consistent with Bloom's taxonomy (Anderson & Krathwohl, 2001) and the improvement in children's skills apparent to the parents/guardians. Fourth, we will include design patterns in games as they promote reuse and pattern recognition. Fifth, we will expose children to technology, such as basic knowledge on the basic functionality and user interfaces that are typical in any smartphone, without a stylus.

2.6 User requirements/analysis of initial perceptions by parents/guardians

To assess parents/guardians' perceptions towards the proposed game, we carried out a perception/user requirements survey. Perception by 11 respondents is mostly positive. Consistent with global parental/guardians' concerns with possible addiction, 70% of the parents, disagree with letting their children with ASD play with video games by themselves. A summary is presented in Table 2.

Table 2. *Perception towards the proposed game design and video games for children with ASD*

Objective	**Question**	**1**	**2**	**3**	**4**	**5**
Perception towards use of smartphones	Children with ASD should be exposed to technology	9.1%	27.3%	18.2%	36.4%	9.1%
Perception towards video games	Children with ASD should not play with video games at all.	27.3%	36.4%	27.3%	9.1%	0%
Perception towards video games & supervision	Without parent/guardian's guidance, children with ASD should be allowed to play video games.	45.5%	27.3%	9.1%	9.1%	9.1%
Perception with regards to educational video games	Video games with elements of education can replace/enrich some activities that the children have in class during the pandemic when school is closed.	0%	0%	9.1%	36.4%	54.5%
Perception towards education and fun.	Video games for children should totally focus on education, and should not have any fun element not related to education.	18.2%	36.4%	18.2%	9.1%	18.2%
Perception towards the design	O.K., easy for the children, good, looks simple and easy to understand (5x), convenient for beginners, neat and still focusing on the basic general user interface without cluttering					

3. Methodology

Primarily, we used incremental waterfall methodology. Object-oriented programming, e.g. via design patterns, is encouraged to enable easy instantiation and diversification. In this project, we also develop based on slight algorithmic permutations, to enable asset reuse; for example, the matching-cum-sorting puzzle. All games involve listening, as one of our aims, is to encourage communication/expression.

3.1 Type of games

Since some children with ASD usually have trouble paying attention for a period of time especially if it concerns matters that do not pique their interest, 4 types of minigames, each with 3 levels, is developed:

a) Categorize (in-house objects): To recognize and categorize objects in the house, and to explore what can be clicked and produce different effects, such as the floor light (Figure 4a).
b) Sorting: To improve problem-solving skills by matching-cum-sorting. Children are asked to distinguish between toys and other objects, such as a table lamp (Figure 4a, b). Children are asked to match shapes. These can become sorting puzzles as well.
c) Puzzle: To improve problem-solving skills by matching puzzle pieces to form the full image according to the sample image (Figure 4c).
c) Filling a Gap/Connecting Pipes (outside the house): This minigame encourages children to explore which pipe fits where among a series of pipes, similar to a puzzle (Figure 4d).

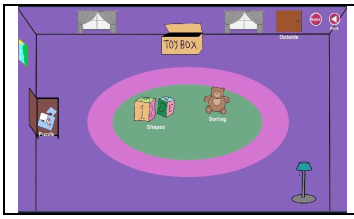

Figure 4a. Categorizing puzzle

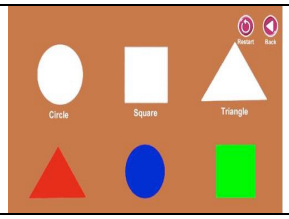

Figure 4b. Sorting puzzle

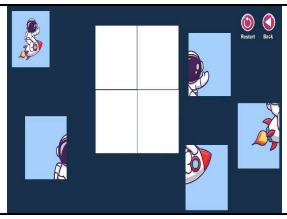

Figure 4c. Parts-of-puzzle

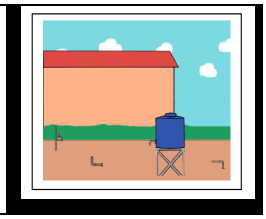

Figure 4d. Connecting pipes

3.2 Development approach, tools and language

The methodology that is used to develop the game is Extreme Programming (XP). The decision on choosing XP methodology over others is because XP is fast-paced, the time frame is short (Kukhnavets, 2018) and there is only one developer, i.e., the capstone student. The tools used to develop the games are Unity, Krita software and a drawing tablet to create custom-made assets. Since Unity is the main software to develop the game, the programming language to develop the game is C#. The smartphone specification used to test the game before distribute it for user testing are: Device Model: POCOPHONE F1, RAM: 6.00GB, CPU: Octa-core Max 2.8GHz, Android Version: 10.

3.3 Method for sampling data

To evaluate technology acceptance, a questionnaire is created and distributed to: a) anyone who is/are a parent or guardian who have a child(ren) who is/are clinically diagnosed with ASD, and b) anyone who may have an understanding or experience meeting with children with ASD. Ten (10) people helped us.

There are three multiple choice sections in the questionnaire, in line with Davis's (1989) Technology Acceptance Model, i.e., a) perceived usefulness, b) perceived ease of use and c) intention to use in the future. We regard perceived usefulness and perceived ease of use as contributing towards user experience and therefore, intention to use in the future. Each question is scored based on a Likert scale of 1 to 5 (1 being strongly disagree, 5 strongly agree). Another section is open-ended, requiring participants to write their comments based on the questions given.

4. Results and Discussion

The primary reasons for technology acceptance were: perceived usefulness (good utility usability goal) and perceived ease of use (easy to learn, easy to remember how to use). These contributed to meeting

enjoyable, helpful user experience goals. The matching/sorting shapes game/puzzle receive positive responses, in terms of perceived usefulness and perceived ease of use, but some parents/guardians' score 2 or 3; possibly due to lack of aesthetics. Augmented Reality (AR) may increase engagement.

Parents/guardians find the filling-the-gap (connecting pipes) puzzle attractive, pleasant, suitable, and easy to understand. Comments given for why they like the games are: "they are fun; suitable for beginners; simple to play but must use strategy to win the game; the games make the children think how to match correctly; by going outside, kids will be more willing to play and learn; easy to understand; encourage children to think more about the solution; and it is simple and easy for them to complete." Further details are presented in Table 3. Scored on a Likert scale of 1 being very disagree and 5 very agree, percentages in Table 3 are for Likert Scale scores of 4 and 5.

Table 3. *Parents'/guardians' post-perceptions towards smartphone use, and video games*

Objective	**Question**	**4**	**5**
Perception towards use of smartphones	I agree that autistic children can use technology such as smartphone and computer to learn and have fun	-16.4%	+80.9%
Perception towards video games			
Perception towards video games & supervision	It is okay for autistic children to play educational games as long as they are monitored by parents/guardians	-9.1%	+90.9%
Perception towards educational video games (virtual substitute)	Educational video games are able to replace certain aspects of going to school physically	-36.4%	+25.5%

Perception towards education and fun (categorizing puzzle)			*Perception towards education and fun (matching puzzle)*		
Likert score	**4**	**5**	**Likert score**	**4**	**5**
PU: This game teaches my children how to distinguish a toy from another object that is not a toy.	20%	60%	PU & PEU: The game *Shapes* teaches my children how to match shapes	0%	90%
PU: Video games can help autistic children to develop better categorizing skills.	10%	80%	PU & PEU: The game *Puzzle* teaches my children how to identify parts of an object and match them.	0%	80%
PU: Video games can help autistic children to develop better matching skills.	10%	80%	I think the children like this game.	20%	70%
PU: Video games can help autistic children to develop better imagination and creating skills.	20%	80%	This game is easy to play.	10%	80%
PU: The game can also teach vocabulary	40%	60%	*Perception towards education and fun (connecting pipes)*		
PU: Video Game can help parents/guardians to communicate better with their autistic children.	10%	70%	PU & PEU: The game is attractive and pleasant, suitable for children.	30%	60%
PU: Video games can help autistic children to express their feelings.		80%	PEU: The game is simple and easy to understand.	20%	80%
PEU: Easy to understand (easy to learn, easy to remember how to use usability goals)	10%	90%	PEU: This game is easy to play.	20%	80%
PEU: Easy to use (easy to learn, easy to remember how to use usability goals)	20%	80%	PU & PEU: I think the children like this game	10%	90%
Will you play this game in the future?	30%	70%	Will you recommend to your friends/family?	20%	80%

*PU = perceived usefulness, PEU = perceived ease of use

5. Implications to Computational Thinking Education and Games Design

Important design factors are: a) more authentic challenges/environments, where the child(ren) can relate and contribute to, b) encourage asset reuse via algorithmic changes and progress to c) less structure, afforded by familiar authentic environments. All activities are different forms of puzzles. Problem-solving such as categorizing objects, are foundational to pattern recognition and connecting pipes, to algorithm design. These games have received positive feedback mainly because of its foci on different skillsets, within the same puzzle framework; akin to Spiro, Feltovich, Jacobson, & Coulson's (1991) CFT. In terms of games design, we need to improve on the aesthetics, and add reflection questions as closure to each gameplay, similar to many CBR-Learning Sciences research.

6. Conclusion

The project has achieved the aims of the project, i.e., to develop a fully functional game that is balanced in fun and educational elements for children, who are clinically diagnosed with ASD. Respondents are positive towards our minigames. Maybe one day, the autistic children will develop their design skills too, in line with IDC.

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