HARNESSING RACING CAR VIDEO GAMES FOR THE LEARNING OF PHYSICS PRINCIPLES BY CHILD WITH AUTISM: A CASE STUDY

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Abstract

Children with autistic spectrum disorders (ASD) have no impairments in the understanding of physical causality and may even be superior relative to mental-age matched controls (Baron-Cohen et al., 1986). Video games, being computer programs are based on logic are thus comprehensible. The game however needs to be of interest, meaningful and engaging for the child (Kee 2009a, 2009b) to persist and persevere for discovery of the logic and skills to win the games. I have personally witnessed my adolescent son with ASD playing with persistence and perseverance until he has won all the trophies available in Sony Playstation 3 video game title "GRAN TURISMO 5 Prologue" in about six months. Apparently, he has developed ability and skills to understand the intricacies of driving a racing car, appreciating the natural law of physics and mechanics without formally learning what it is. Essentially, the case study explores and narrates the process of bridging the tacit learning from games to the learning of academic subjects through mediated learning experience. It is the intention of this paper to provide an example and potential model for educators to explore harnessing the learning from video games for the learning of academic subjects in the 21st century.

Keywords

Autism – Video Games – Academic subjects

Introduction

Children with ASD having no impairments in understanding physical causality (Baron-Cohen et al., 1986) are often found pressing buttons of lifts, DVD players, and electronic gadgets. Pressing buttons where the cause and effect linkage are almost immediate, provides comprehensibility, familiarity and understanding of the construct of causality.

> Video games are essentially computer programs where the basic construct is logic and thus causality. Decision making, looping and sequencing, the basic logic of computer programs are determined by causality of

> input➔process➔output fundamental flow constructs. Thus children with ASD will be able to understand video games. If the video game captures their interest long enough, they will be able to systematize and figure out the logic from regularity of observed input with predictable output outcome. (Kee, 2010:4)

Children with ASD are thus found to be highly interested and motivated by computers (Goodwin, 2008; Grynszpan, Martin & Nadel, 2007) and even more so with video games (Kee, 2009a, 2009b) which are engaging and immersive. Moreover, learning environments that are visual with structure, organization, clarity with predictable sequence of activities (Mesibov, Shea & Schopler, 2004), will naturally appeal and address needs of the culture of autism (Mesibov, Shea & Schopler, 2004). Prensky (2006) consider our kids to be digital natives, belonging to the game generation whereas we are just immigrants in this information age. He strongly advocates digital game-based learning as it prepares the child for the 21st century needs with different types of learning (Prensky, 2007: 156). James Paul Gee (2007a), a professor of literary studies at Arizona State University, has written a book "What video games have to teach us about learning and literacy" that expounds how video games supports 36 learning principles and collected essays to how good video games are used (Gee, 2007b). Similarly, special educators should also seriously consider digital game based learning using video games in helping children with ASD learn, as the visual logic and interface naturally make sense to them. However, research on the educational use of the Commercial Off-The-Shelf (COTS) video games in special education, is relatively unexplored compared to mainstream education (Kee & Chia, 2010).

The current study explicates the 'how and why' research question (Yin, 2009) of using a racing car video game for the learning of suitable Physics principles by a child with autism for potential generalization to theoretical propositions (Yin, 2009) of harnessing video games for learning in the 21st century by children with autism and possibly typically developing individuals. Thus case-study research methodology has been adopted (Yin, 2009).

1. Literature Review

1.1 Choice of Gaming Platform (Kee & Chia, 2010)

Dedicated game consoles with large screens are preferred over portable game consoles, mobile games or computer games on desktop/notebook computers as human mediator can observe and mediate learning of subject with this setup. Dedicated game consoles generally are designed for robust and "idiot proof" handling and built with incorruptible game operating system, which are stable with reliable hardware. On the other hand, video games running on Nintendo DS, Sony Personal Playstation (PSP) or on Windows Mobile, iPhone and Nokia phones have screens which are rather small and impedes one from seeing the screens to assess progress of learning in game play, needed for effective human mediation of learning (Kee, 2011).

1.2 How are suitable games determined?

Personal experiences reveal that one cannot dictate the games they will play from observation of my three adolescent sons with ASD to different degrees whom starting playing video games at about age four. However I will screen and select games without undesirable traits such as sexual, criminal, witchcraft violence (scenes of blood and gore) themes and are not designed with the General Aggression Model (Anderson et al., 2007).

> The taste and choices of my children do change as they mature and currently I do find difficulty selecting games for my eldest son of sixteen years of age. He seems to prefer first person shooting games with "violence" and "realism" which I disallow. As he has mild ASD and is attending mainstream school, he plays only when my selected games appeals to him such as "Wii Resort". However, my two other younger sons with ASD and in special schools do not mind my selections. I have found Nintendo game consoles running family friendly Nintendo game titles such as "Animal Crossing: City Folk", "Pokémon Battle Revolution", "Mario Kart Wii", "Super Mario Galaxy", "Super Paper Mario" and "Mario Super Sluggers" are suitable. Sony Playstation 3 console titles "LittleBigPlanet" and "Gran Turismo 5 Prologue are also well liked by my youngest son.
>
> (Kee, 2010: 11).

Essentially, selected video games should provide a visually engaging, immersive and meaningful learning environment with activities (Jonassen, et al., 2008; Kee, 2009). Generally, the game provides a form of student-centred learning environment (Jonassen & Land, 2000) that children naturally do not mind spending substantial time to explore and have fun. Making mistakes and learning from mistakes (Shank, 2002) without reprimand but rather with fun and humour should be evident.

1.3. Need for Human Mediation of Learning

Most neurotypical people learn meanings of words by their association of "hearing those noises as they accompany actual situations in life" (Hayakawa and Hayakawa, 1990: 36). Children with ASD have difficulties in social interactions and communication (Baron-Cohen, 2008; Kee, 2011) and will thus miss a lot of cues and opportunities for learning through social-cultural interactions. The lack of social-cultural interactions has to be remediated through a significant human who understands the child well enough to explicate and make explicit the thinking processes using appropriate vocabulary. Sustained reinforcement of the learning through multiple social interaction is needed for reliable construction of meanings derived from social transactions. The process is the product for development of appropriation (Rogoff, 1990: 195).

I would strongly recommend the consideration of Professor Reuven Feuerstein Mediated Learning Experience (Feuerstein, Klein, & Tannenbaum, 1999) as a framework for mediating. Chandler (2007) has expounded in her book "Semiotics: The basics" that "meaning is not transmitted to us – we actively

create it according to a complex interplay of codes or conventions we are normally unaware" (p. 11). The significant human needs to repeatedly provide opportunities for children with ASD in day to day interactions, to allow generalizations to develop through systematizing of similarities between new and old observations, in everyday cognition (Rogoff and Lave, 1999). Simply put, consider the child with ASD to be the apprentice of learning everyday cognition (Rogoff, 1990; Rogoff and Lave, 1999) from the significant human.

> "However, my two younger sons with ASD and in special schools do not mind my selections. I have found Nintendo game consoles running family friendly Nintendo game titles such as "Animal Crossing: City Folk", "Pokémon Battle Revolution", "Mario Kart Wii", "Super Mario Galaxy", "Super Paper Mario" and "Mario Super Sluggers" are suitable. Sony Playstation 3 console titles "LittleBigPlanet" and "Gran Turismo 5 Prologue are also well liked by my youngest son." (Kee, 2010: 11).

1.4 How to harness video games

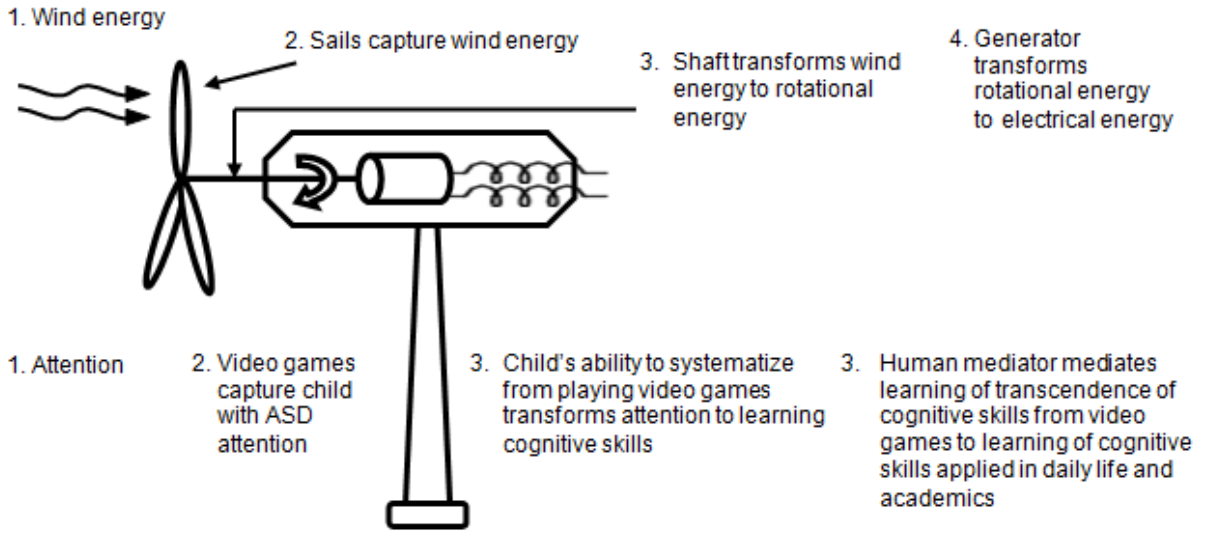

Figure 1. Analogy of windmill to show how video games can be harnessed. Reproduced with permission from Cobee Publshing House and author (Kee, 2010: 6)

Harnessing video games as illustrated in Figure 1, involves knowing what the child has already systematize from playing the video game that exemplifies grasping the concepts applied in game play (Kee. 2010).

2. Research Design

Case study research methodology (Yin, 2009) is selected as the research question focuses on the "how" and "why" of harnessing racing car video games for learning of suitable Physics concepts. Moreover, researcher has little or no control over which video game as well what content will interest the child as well as whether the child will persist and emerge winning the game activities. In any case, the focus is on a contemporary phenomenon. Youths and adults have been

used observed to play COTS video games in airports, trains, public transports as well as shopping malls. Finally, the intention is to generalize to theoretical propositions (Yin, 2009) of potential of harnessing video games for learning of academic content and not to populations or universes.
The research methodology adopts Yin (2009) five components of research design, where there is a single unit of analysis; a mildly autistic child, age 14 with IQ of 72 currently enrolled in a special school in Singapore.

2.1 Study Research Question and Corresponding Study Propositions (CSP)

My research questions and their CSP (Yin, 2009) are:
Q1. Why is racing car video game appropriate for learning of suitable physics principles by subject with autism?

> CSP1: Racing car video games provide a learning framework for the child with autism to build the sense of Physics concepts.

Q2. How can one harness racing car video game to learn suitable physics principles by child with autism?

> CSP2: Racing car video games provide the experiences that built the sense and appreciation of applied Physics concepts that can be harnessed through mediation of learning the terms used in Physics to describe the learnt concepts.

2.2 Unit of Analysis

The unit of analysis is a male adolescent subject of age 14 with mild autism and intelligence quotient of 72. He is currently attending a special education school in Singapore and who has played video games since the age of four.

2.3 Logic linking the data to the propositions and criteria for interpreting findings.

CSP1: Racing car video games provide a learning framework for the child with autism to build the sense of Physics concepts.
Evidences in this study to support this proposition are from two perspectives. Firstly to analyze and make explicit from recorded game play of evidences of a learning framework where subject becomes engaged, immerse in game play with meaningful learning of video game constructs (Kee, 2009a). Secondly, to analyze and make explicit from recorded game play of evidences that build the sense and appreciation of the concepts of inertia, friction, acceleration and deceleration.

The critical criterion for effectiveness is in the performance of the subject to use the terms used in Physics for the appropriate association with events in new video clips through mediation of transcendence (Kee, 2011).

CSP2: Bridging the learnt Physics concepts in game play to actual terms used in Physics concepts by mediated learning experience results in learning of academic Physics.
Evidences to support this proposition will be from determining the effectiveness of bringing the concepts incidentally learnt by subjects from selected clips of video to terms used in Physics by mediating learning action (Kee, 2011).

3. Validity of Design

3.1 Construct Validity

Evidences of subject grasping concepts of Physics as seen by knowledge into action (Kriz, 2009) will be gathered from multiple sources of evidence (checking captured video, interviewing subject to establish chain of evidence of understanding). For example, subject was observed to slow down repeatedly before making any sharp turns by braking and/or increasing value of TCS (Traction Control System). Subject was questioned as to why he slowed down before the turns and why he increased the TCS value before the turn to verify and clarify. In the process, mediating the learning of terms used in Physics (friction and inertia) through subject's incidental learning was attempted. Perhaps, it may also be reframed as game debrief through mediator, of action-to-knowledge and integrating-action-knowledge (Crookall & Thorngate, 2009).

3.2 Internal Validity

Internal validity of the constructs for establishing grasping of Physics concepts in game play was established through observation of three or more consecutive evidences in game play of sequence of actions depicting knowledge into action. For example, if subject consistently slowed down before negotiating sharp bends then subject is considered to have grasped the concept of friction and inertia, even though subject may not know the terms. He is also an experienced roller blades user where control in negotiating turns is observed.

3.3 External Validity

People with autism think in details rather than generalizations (Grandin & Barron, 2005). Multiple examples of visual images and experiences are therefore needed to form part of their mental database, where they can work with to form generalizations (Grandin, 2006). These details are assembled where similarities and differences are then sorted out for the generalized concept formation (inductive thinking). Neurotypical people learn otherwise where the generalized concept (deductive thinking) is taught first and learning from examples comes after. The study is an attempt to investigate the theoretical framework where multiple pictures and multiple concrete experiences are needed before people with autism can make sense of the generalized concept in Physics. Mediation of transcendence (Kee, 2011) will also be needed to reinforce and create familiarity with terms used.

3.4 Reliability

The reliability of the research is established by using a case study protocol. This involves establishing grasping of Physics concept in game via observation of three consecutive instances in game play and questioning subject on whether the actions were intentional with reasons obtained directly from subject. Mediated learning approach (Kee, 2011) was used to harness the learning from the video game to the learning of suitable Physics concepts.

4. Video Game Setup

Sony Playstation 3 Slim version (250G) console running Sony game title: "Gran Turismo 5 Prologue" with HDMI output to 42 inch full HDTV was used. Resolution of the display was set at 1080i (1920 x 1080) and not 1080p due to Hauppage HD PVR limitation. Other equipment used includes two HDMI splitters, one HDMI to component video converter and a Wintel I7 notebook for capturing and processing video input.

5. Findings

CSP1: Racing car video games provide a learning framework for the child with autism to build the sense of Physics concepts.

Figure 2. Evidence of attaining the different driving classes

Yes, it does. Subject was able to play with passion for hours and there was a need to built-in 15 minutes break for every hour of play. The racing car video game was able to provide appropriate levels of difficulty and challenges for subject to become engage and to persist repeatedly through trial and error for mastery of game play (see Figure 2), implicating a meaningful and developmental learning framework. Perhaps, the highly photo realistic color, fast rendering and realistic real racing simulation, provides an engaging and immersive environment, where subject was not only able to make sense of the interface but also win all levels and complete the game. I am inferring that repeated trials with final success built a sense of understanding the physics behind driving a car. For example, initially subject would crash before making a sharp turn. Eventually subject learns to slow down before turning. However, as he could not win by slowing down too much, he then learnt to use the game option of Traction Control System (TCS). This allowed subject to have minimal loss of speed during turns and win. Evidence of learning was also established through asking the child to comment on the purpose of the artefacts designed in game play and the rationale for the decisions he made, as the captured video was played back. Thus multiple sources of evidences were used to establish CSP1.

CSP2: Bridging the learnt Physics concepts in game play to actual terms used in Physics concepts by mediated learning experience results in learning of academic Physics.

The initial attempt was faced with challenges of having to unpack the meaning of the terms used in the formal definition of Physics terms such as friction.

Chew, Chow and Ho (2007: 57) textbook "Discover Physics GCE 'O' Level Science" defined friction as "When two surfaces are in contact and one surface moves, friction is the force that opposes the direction of the motion". As subject does not have formal education, terms such as surface, contact, force, opposes and direction of the motion needs to be explained with experiences and objects that subject is familiar with. For example, I used a board pasted with four types of surfaces with increasing roughness and thus increasing frictional force, tilted slightly for gradient, so that a Penguin toy with rollers can roll down at different speeds for subject to experiment (see Figure 3). The setup was used to help subject construct the understanding of the terms used in the definition.

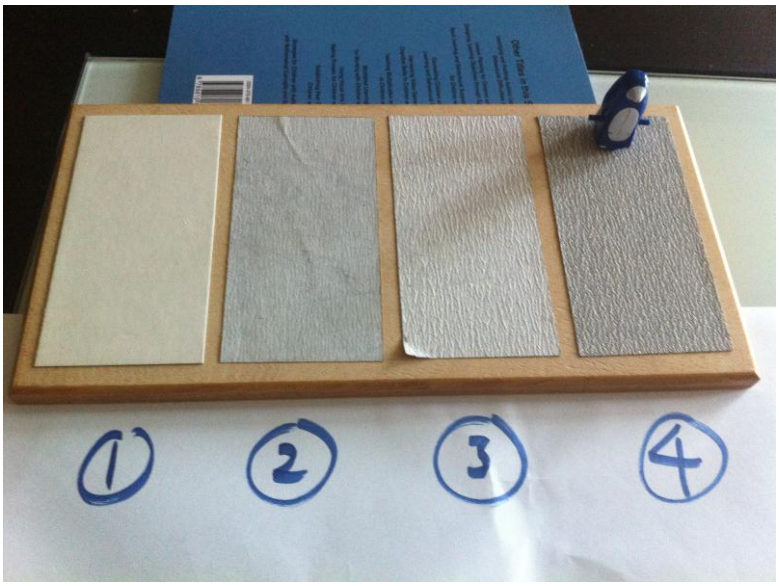

Figure 3. Setup to teach terms used in Physics

Thereafter, it was related to the video game experiences and context to bridge the understanding of what subject was already familiar. Mediation of transcendence of terms were done when and where appropriate in daily living situations for subject to internalize the terms of concepts. For example, he was questioned as to why he did not slipped while walking with his slippers.

6. Discussion

Racing car video game is appropriate for learning of suitable physics principles by subject with autism as it provides an engaging, immersive and meaningful learning framework that allows the construction of Physics knowledge in action via the game construct. The main challenge is to mediate the informal learning into what is expected in formal learning. Through the current study, many terms and concepts used in the definition have to be co-constructed with the subject, in

association with familiar experiences for accommodation (Rogoff, 1990). As the game strives to simulate real racing, Physics concepts were applied into the mechanics of the game. Mastery of the game would by implication involve mastery of the logic behind the game and thus Physics concepts. Subject ability to systematize leads to mastery. However, learning terms used in formal education that describes the learnt concepts requires socio-cultural learning of "Action into knowledge" from familiar experiences. Mediation of transcendence needs to be intensive before the terms become internalized and voluntarily used.

An interesting finding from studying the captured video revealed that subject is able to take advantage of driving options that disadvantage the computer competitors to win the game. For example, subject reduces the artificial intelligence of the competing drivers to 25%, which in effect, reduces their intelligence and ability to problem solve and overtake him, allowing subject to win in Arcade mode. However, this option is not available for the class mode.

Conclusion

The current study is an attempt to provide an example of how to harness video game informal learning for formal learning. The study documents the merits of informal learning from video games and also the challenges to mediate (Kee & Chia, 2010; Kee, 2011) to formal learning, lies mainly in acquiring the terms used in formal learning, which are socially constructed through learning situations and use (Chandler, 2007). The limitation of the study is the involvement of only one subject with high functioning autism. The current study suggests the possibility of people with autism to learn the sciences which are generally not part of the formal curriculum in special education.

References

Anderson, C.A., Gentile, D.A., & Buckley, K.E. (2007), Violent video game effects on children and adolescents: Theory, research, and public policy, New York, NY: Oxford University Press

Baron-Cohen, S., Frith, U., & Leslie, A.M. (1986), Mechanical, behavioural and intentional understanding of picture stories in autistic children, British Journal of Developmental Psychology, 4(2), 113-125

Chandler, D. (2007), Semiotics: The basics (2nd Ed.), New York, NY: Routledge

Chew, C. , Chow, C. S. & Ho, B. T. (2007), Discover Physics: GCE 'O' Level Science, Singapore: Marshall Cavendish Education

Crookall, D., & Thorngate, W. (2009), Acting, Knowing, Learning, Simulating, Gaming, Simulation Gaming, 40(1), 8-26, doi: 10.1177/1046878108330364

Feuerstein, R., Klein, P.S., & Tannenbaum, A.J. (1999), Mediated learning experience (MLE): Theoretical, psychosocial and learning principles, London, UK: Freund Publishing House

Gee, J.P. (2007a), What video games have to teach us about learning and literacy, New York, NY: Palgrave Macmillan

Gee, J.P. (2007b), Good video games + good learning: Collected essays on video games, learning and literacy, New York, NY: Peter Lang

Goodwin, M.S. (2008), Enhancing and accelerating the pace of autism research and treatment: The promise of developing innovative technology, Focus on Autism and Other Developmental Disabilities, 23(2), 125-128

Grandin, T. (2006), Thinking in pictures: My life with autism (2nd ed.), New York, NY: Vintage Books

Grandin, T. & Barron, S. (2005), Unwritten rules of social relationships: Decoding social mysteries through unique perspectives of autism, Arlington, TX: Future Horizons

Grynszpan, O., Martin, J.C., & Nadel, J. (2007), Exploring the influence of task assignment and output modalities on computerized training for autism, Interaction Studies: Social Behaviour and Communication in Biological and Artificial Systems, 8(2), 241-266

Hayakawa, S. I., & Hayakawa, A. R. (1990), Language in thought and action (5th Ed.), Boston, MA: Harcourt

Jonassen, D.H., & Land, S.M. (2000), Theoretical foundations of learning environments, Hillsdale, N.J: Lawrence Erlbaum Associates

Jonassen, D., Howland, J., Marra, J., & Crismond, D. (2008), Meaningful learning with technology (3rd Ed.), Upper Saddle River, NJ: Pearson Education

Kee N.K.N. (2009a), Informal learning from video games of three autistic children in a family: A case study, The Journal of Reading & Literacy, 1(1), 45-60. Retrieved October 1, 2009, from: http://www.srl.org.sg/www/downloads/JRL_Vol1_No1_2009.pdf

Kee N.K.N. (2009b), Harnessing commercial off the shelf (COTS) video games in special education: A retrospective reflection of pedagogy and learning observed with three autistic children in game play, Paper presented at "Learn to Game, Game to Learn" International Simulation and Gaming Association 40th Annual Conference 29 June to 3 July 2009, Singapore (pp.1-8). Singapore: The International Simulation and Gaming Association

Kee, N. K. N. (2010), Harnessing Video Games to teach Cognitive skills to Children with Autism. In Practical tips on teaching children with mild/moderate autism in mainstream schools, Singapore: Cobee Publishing House

Kee, N. K. N. (2011), Mediated Learning Approach for Working with Children with Autism. In Practical tips on teaching children with mild/moderate autism in mainstream schools, Singapore: Cobee Publishing House

Kee N. K. N. & Chia K. H. (2010), Mediated and engaged learning using COTS video games in ASD special education, In Cai Y.Y. (Ed.), IDM and VR for Education in Virtual Learning Environment, New York: Nova Sciences Publishers, 140-159

Kriz, W. C. (2009), Bridging the Gap: Transforming Knowledge Into Action Through Gaming and Simulation, Simulation Gaming, 40(1), 28-29

Mesibov, G.B., Shea, V., & Schopler, E. (2004), The TEACCH approach to autism spectrum disorders, New York, NY: Springer Science+Business Media

Prensky, M. (2006), "Don't bother me Mom, I'm learning!": How computer and video games are preparing your kids for twenty-first century success and how you can help!, New York, NY: Paragon House

Prensky, M. (2007), Digital game-based learning, New York, NY: Paragon House

Rogoff, B. (1990), Apprenticeship in thinking: Cognitive development in social context, New York, NY: Oxford University Press

Rogoff, B., & Lave, L. (1999), Everyday cognition: Its development in social context, London, UK: Harvard University

Schank, R. C. (2002), Designing world-Class E-Learning, Columbus, OH: McGraw-Hill

Yin, R. K. (2009). Case Study Research: Design and Methods (4th Ed.), Thousand Oaks, CA: Sage Publications