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<th>MLE for children with autism in the digital learning environments</th>
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<tr>
<td>Source</td>
<td>B. L. Chua &amp; Y. F. I Wong (Eds.), <em>Mediated learning experience: Applications in various contexts</em> (pp. 1-20)</td>
</tr>
<tr>
<td>Published by</td>
<td>Mediated Learning Laboratory, Psychological Studies Academic Group, National Institute of Education</td>
</tr>
</tbody>
</table>

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Citation: Kee, K. N. N. (2016). MLE for children with autism in the digital learning environments. In B. L. Chua & Y. F. I Wong (Eds.), *Mediated learning experience: Applications in various contexts* (pp. 1-20). Singapore: Mediated Learning Laboratory, Psychological Studies Academic Group, National Institute of Education.

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Children with autism do not have any impairments in systematizing ability (Baron-Cohen, Frith, & Leslie, 1986), that is, they are able to figure out how things work based on consistent rules or patterns. If they are given sufficient time to make sense of happenings in nature and/or in our artificially created human environment, children with autism do have the cognizant ability to make sense of causality constructs in living. Courchesne et al. (2007) reviewed two decades of literature on neurobiology of autism and provided evidences that at birth, the brain of children with autism is “near normal or slightly below the normal average” (p. 401) but abnormal accelerated growth of the brain was found thereafter until about 4 years of age when it abnormally slows down or stops.

Based on the graph Courchesne et al. (2007) drawn on early brain overgrowth of children with autism during the first years of life with comparison to typically developing, the head circumference of children with autism became the same as typically developing children at about three months. Owens, Farinella and Metz (2015) described that infants learn stimulus-response sequences, a pre-language development, during the first three months, such as, crying signal for caregiver to respond and bottle signal from mother as response for feeding. The neurobiology finding and pre-language development explains why there is no impairment in children with autism to understand stimulus-response sequences or causality.

Recent research findings in neurology (Courchesne et al., 2007; Sacco, Gabriele & Persico, 2015; Grandin & Panek, 2013) and other
aspects of autism (Singletary, 2015), have also further provided an integrated insight on why digital learning environments are apt for people with autism to learn with (Attwood, 2007; Goodwin, 2008; Grynszpan, Martin, & Nadel, 2007; Kee, 2009; Kee, 2010; Kee & Chia, 2011). Digital learning environments are essentially running computer programs that are built based on logic of sequencing, decision making and looping, and thus causality. However, for the learning of the signified and the signifier in the semiotics of human language (Chandler 2002), Mediated Learning Experience (MLE) will be needed to support and direct children with autism to socio-culturally construct the intended meanings that have cultural bias and specificity. The current chapter will provide the theoretical background and suggest practical ways of applying MLE in the digital learning environments.

**Theoretical Framework**

Brief integrative update of autism in relation to digital learning environments

Autism Spectrum Disorders or autism is commonly known by people through direct interactions to have difficulty in social interactions, communicating with clarity and to exhibit behaviours that are clearly unique and atypical. These three traits are known as the triads of impairments (Engeland & Buitelaar, 2008). As the etiology and genetic markers of autism have not been established as conclusive and definitive to detect autism impairments (Engeland & Buitelaar, 2008), the current available means to diagnose the condition of autism is via behavioural observations. The two most popular and commonly used diagnostic frameworks are DSM-5 (American Psychiatric Association, 2013) or ICD-10 Version 2016 (World Health Organization, 2016). Since behavioural observations are subject to potential variability in degrees of perception, there may be some variances in identification. Nevertheless, behavioural observations remain as the best available means to-date for diagnostic assessment of autism.

There are substantial empirical reports that children with autism are significant stressors for parents, teachers and caregivers (see Chua, 2012 for review). Recently, with integrated reviews from diverse
research findings on autism (Courchesne et al., 2007; Singletary, 2015), the brain of the children with autism have been found to be different from typically developing.

At birth, the brain of the typically developing and the brain of children with autism are about the same. However, after birth, researchers have consistently found accelerated growth of the brain of the children with autism, such that by 2 to 4 years of age, there is about 10% greater increase in brain circumference, volume and size (Courchesne, et al., 2007; Engeland & Buitelaar, 2008; Grandin & Panek, 2013; Sacco, Gabriele, & Persico, 2015). The scenario after about 5 years of age changes drastically, where the growth of the brain of children with autism becomes abnormally slow or arrested (Courchesne, 2004). The typically developing child will continue in brain development as the child grows to becoming an adult and even after.

The anomaly of increase of brain matter has been reported with diverse findings. Most researchers (Courchesne et al., 2007; Engeland & Buitelaar, 2008; Grandin & Panek, 2013; Kayoma, 2009; Sparks et al., 2002) agreed that increases were found in the frontal lobe, the temporal lobe, the cerebellum and the amygdala regions of the brain.

The frontal lobes manages higher mental functions of the brain like planning, personality, memory storage, complex decision making and language and also helps in the controlling emotions through connections with the limbic system which includes the amygdala (responsible for fear responses and fear memory) (Ciccarelli & White, 2012). The frontal lobes of children with autism were found to have non-uniform overgrowth (Carper & Courchesne, 2005) and the variation rather than uniformity in growth possibly explains the diversity in higher mental functions among children with autism.

Moreover, Minshew and Williams (2007) review of the neurobiology of autism found disorder in the connectivity of association between different regions of the brain but intact or enhanced abilities on local neural connections. The implications in terms of seeing, are that highly detailed concrete visual information will be noticed and brought into attention, due to high concentration of frontal lobe local
nerve cells processing the received visual information. This probably explains why people with autism were found to have superior detail-focused cognitive style (Happe & Frith, 2006), superior visual search abilities (Joseph, Keehn, Connolly, Wolfe, & Horowitz, 2009; O’Rioran et al., 2001) and precise minds (Cruys et al., 2014). However, due to poor association connectivity with other brain regions, they have difficulty to “see the big picture” or weak central coherence (Happe & Frith, 2006; Mesibov, Shea, & Schopler, 2004) and reduced ability to guess what others may be thinking or “theory of mind” (Rajendran & Mitchell, 2007).

The strong visual processing bias is an advantage and strength for children with autism to possess especially in digital learning environments, where the predominant output is visual display (e.g., ipads, digital watches, computer displays, personal digital assistants and television displays). Mazurek and Wenstrup (2013) found children with autism to spent approximately 62% more time watching television and playing video games than all non-screen activities combined, while Shane and Albert (2008) found more time by persons with autism was spent engaged with electronic screen media than any other leisure activity. Mineo, Ziegler, Gill and Salkin (2009) devised a way to study electronic screen media by collecting a baseline data for others to follow up. Children with autism will be able to eventually discover and make sense if the design for learning and the design of learning are fundamentally sound.

The design for learning refers to the scope and sequence for learning content, process or product, that is, the curriculum. In terms of MLE, the design for learning requires analysis of the learning task to produce the cognitive map which has 7 task dimensions (Feuerstein R., Feuerstein, R. S., Falik, & Rand, 2002). The 7 dimensions are 1:content (familiar, unfamiliar, substitution to familiar alternatives), 2:modality (i.e., modes for presentation and responding: verbal, pictorial, numerical, figural and others), 3:phase (i.e., input, elaboration, output – all three are affected by affective motivational levels), 4:operations (i.e., cognitive/thinking skills like organization, classification, seriation, comparison, analogy and many with other cognitive functions), 5: level of complexity (simple to complex), 6:level
of abstraction (concrete to abstract) and 7: level of efficiency (i.e., rate, precision and effort).

The design of learning refers to the pedagogy of the learning, that is, the details of the strategies to engineer learning by participant to take place with feedback, verification and encouragement. In MLE, the design of learning requires the mediator to be effective in three critical core criteria of mediation - mediation of intentionality and reciprocity, mediation of meaning and mediation of transcendence. In any case, there is a caveat that the mediator must fundamentally be convinced and act in conviction the five important beliefs of Structural Cognitive Modifiability (SCM), which essentially views all humans and their characteristics, regardless of age or degrees of disabilities, to be modifiable (Feuerstein, Rand, & Feuerstein, 2006).

In mediation of intentionality and reciprocity, the effective mediator will need to leverage on excellent understanding of learner to devise ways to “change the ‘state’ of the child, rendering him more vigilant and positioning him so that he is more ready to the stimulus” (Feuerstein, Rand, & Feuerstein, 2006, p.64). The mediator will certainly need to take note of affective motivational levels of learner and consider ways to motivate the learner with positive attitude when needed (Feuerstein, Rand, Hoffman, & Miller, 1980). Most importantly, the learner should be appropriately helped to perceive the stimulus of learning with clarity and precision by any possible means. For example, using characters of affection, like “Thomas the Train” or “Pikachu” to direct or catch attention so that the learner reciprocates. Other strategies such as changing amplitude of stimulus (i.e., increasing or decreasing loudness of sound or light intensity such that stimulus attracts learner’s attention), changing sound effects or colours of light and changing duration of stimulus long enough for learner to notice. After catching attention, the mediator should transform the mental, emotional and motivational state of learner to be ready for learning.

Feuerstein, Klein and Tannenbaum (1991) explains that the mediation of meaning addresses why the learner should bother to pay attention and learn what mediator wants. It addresses the “energetic dimension of the interaction; it answers the question of why, what for,
and other questions related to the causal and teleological relationship reasons for something to happen or to be done” (p.24). In other words, the learner needs to perceive that the learning activity has personal value with potential for meaningful use. It is my personal observation that many of the school textbooks or workbooks used, do lack the mediation of meaning of the curriculum materials for application into our daily lives. Though there are encouraging signs that more textbooks are beginning to appear to address the need to apply the learning into our daily lives. For example, Chaille and Davis (2016) produced the text “Integrating Math and Science in early childhood classrooms through big ideas: A constructivist approach” is one such example.

Finally, in the mediation of transcendence, the mediator has to create opportunities and expose the learner to diverse situations or context in life which mandates the application of the learning. This practice provides opportunity for the learner to appreciate how the same learning unit can be applied under different conditions in a larger, more meaningful and engaging context. The opportunity for generalization and internalization of learning moves the depth of learning from deductive understanding to inductive understanding of usefulness of learned unit. Feuerstein et al. (1991) defined it as “the orientation of the mediator to widen the interaction beyond the immediate primary and elementary goal, creates in the mediate a propensity to enlarge his cognitive and affective repertoire of functioning constantly” (p. 21-22). Chaille and Davis (2016) consider it to be the development of big ideas where the learner has deeper understanding rather than superficial, disconnected content knowledge, or the acquisition of facts.
The initial preparation involves knowing the details of the digital learning environment in which the child spends a substantial amount of quality time playing. The mediator will need to either directly observe the child’s area of interest in game play or indirectly learn from the caregivers of the specific scenarios or game levels where the child has demonstrated mastery of the digital environment. The intention is to leverage or harness the learning from video games like harnessing wind energy from a windmill (Kee, 2010) (see Figure 1).
Figure 1. Analogy of windmill to show how video games can be harnessed.

(Reproduced with permission from source: Autism – Practical Tips on Teaching Children with Mild/Moderate Autism in Mainstream Schools: Harnessing Video Games To Teach Cognitive Skills To Children with Autism, Page 6 – figure 1, Cobee Publishing House, October 2010)
“Similarly, video games (windmill sails) naturally attracts the attention of a child with ASD (wind energy), such that the child willingly stops doing other things and focuses his energy and attention (concentrating wind energy) to systematize the game activity, and in the process, understanding the activity (rotational energy) through trial-and-error practices, observations and learning from mistakes. The more the child is able to make sense of the video game (greater effectiveness), the more the child’s energy to focus and learn (concentration of wind energy) will be harnessed. (Kee, 2010, p.7)

A detailed example of mediation using Nintendo Game: “Animal Crossing: City Folk” for the teaching of cognitive skills has been published (Kee, 2010) for children with high functioning autism. Another detailed example of the thought processes involved for effective mediation in the teaching of division using Montessori Division Board has also been published (Kee, 2011).

I have found that, as a special educator, as a father of children with autism and through informal interactions with many parents, video games had provided high engagement and meaningful learning for their children with autism, though the learning may not be relevant to academic learning. Many parents have also reflected the concern of violence in video games to influence development of aggression in their children. Rigby and Ryan (2011) found that “the extra blood and gore added nothing to their “fun” as other aspects of gameplay (the competence feedback, the opportunities to choose actions, etc.) were equivalent” (p. 125). Thus wise selection of non-violent, good and endorsed video games would mitigate the concern. These video games may run on game consoles (e.g., Sony Playstation 3 or 4, Nintendo Wii or Wii U, Microsoft X-Box 360 or One), dedicated portable game players (Sony Vita, Nintendo 3DS), mobile phones running android or iphone operating systems or personal computers (e.g. desktop, notebooks, tablets). Often, the gaming experiences provided meaningful learning for the child with autism, which may be seen by the child’s active engagement in active, constructive, intentional,
authentic, and cooperative learning (Jonassen, Howland, Marra, & Crismond, 2008).

Digital learning environment in this chapter has been operationalized as the environment where the computer technology (e.g. personal computer, personal digital assistants like ipad, mobile phones, game consoles like Nintendo Wii U, portable game consoles like Nintendo 3DS) provides meaningful learning for the child with autism.

Often, the digital learning environment involves the use of video games. Rigby and Ryan (2011) have aptly and richly described the reasons for the strong allure and predominance of video games in more than 100 million people lives in the United States alone. Their rich research involving more than 30 years on human motivation and psychological health, and more than seven years on games involving an excess of 20,000 gamers across all types of games, lead to the development their model of Player Experience of Need Satisfaction (PENS) to explain the phenomenon. Essentially, Rigby and Ryan (2011) explained that the allure was mainly due to the ability of video games to satisfy specific intrinsic needs of competence, autonomy and relatedness. People with autism have intense interest in video games are not different from typically developing children and even more so when there is no impairment in understanding of causality (Kee, 2009, 2010, Kee & Chia, 2011).

The games that appeal to children with autism are diverse from different genres and will depend on the personal likings of the child with autism. My three sons with autism were found to have different interests in different games (e.g., sports, adventure, strategy, action) and their interests had changed with growth, development and level of sophistication in game play. Thus there is a need to investigate or verify the current interest of the child for MLE and not assume their interest.
Step 1: Preparation

The degree to which children are able to appreciate and learn new knowledge depends largely on the fidelity of their background knowledge to support or link with new learning so that it makes sense. The intention for mediation in this chapter is to effectively leverage on the background knowledge, skills and understanding that the child with autism has already developed, learnt and mastered from the digital learning environment. The main pedagogies are mediating learning by association and mediating learning by analogy of the familiar with the unfamiliar, by teaching them to see similarities, to see differences, to create analogies and to create metaphors (Apthorp & Dean, 2012).

Nintendo’s Animal Crossing Amiibo Festival, an electronic board game with human computer interactions that requires players to take turns using Amiibo’s (i.e., game play tokens) to tap on the Wii U game console for rolling the dice, will be used as an example. Assuming that the child had intense interest in playing the game and had won the game, mastery of the digital learning environment would be a logical deduction.

As the child is already familiar with the artefacts (i.e., objects in the background), affordances (e.g., selection buttons that causes something to happen), signifiers (i.e., the language used in game play such as bells), signified (i.e., meaning of the language used
where bells are like money or currency for exchange) and social interactions within the social cultural environment of animals living together (e.g., turn taking in daily living for a month in a year), all the rich and familiar elements of the game environment may be harnessed for learning.

In order to make reference to the child’s familiar digital learning environment, snapshots of gameplay may be captured by simply using a digital camera/digital video camera or even by googling uploaded pictures or videos. The captured picture context may then be used to teach functional literacy curriculum of language (e.g., different colours of the background), social skills (e.g., taking turns), mathematics (e.g., counting the number of spaces) and orientation in space (e.g., directions such as left, right, down, up) and even higher cognitive skills (e.g. strategic thinking).

The mediator should deliberate on opportunities to mediate learning or the zone of proximal development (Kee & Chia, 2011). For example, the “Stalk market” in gameplay is analogous to our real life “Stock Market”. Ability to learn processes involved in Stalk Market provides analogous insight on buying/selling shares, opportunity cost, sensible buying of groceries by scanning for offers from different sources and so on.

**Step 2: Mediation of Intentionality and Reciprocity**

The goal of the learning activity is to appreciate the main processes operating in the Stock Market of Singapore. The pedagogy adopted is learning by analogy of the Stalk Market in “Animal Crossing: Amiibo Festival” with the real Stock Market of Singapore.

The mediator then needs to assess whether the child is ready to engage in conversation about his Stalk Market activities. If ready, praise the child for that you have observed him making a lot of bells and becoming very rich. Bring the child to the Stock Exchange of Singapore. Take some photographs where possible. Check for response of interest in learning about the Stock Exchange. If child responds positively, then move to mediation of meaning.
Step 3: Mediation of Meaning

The goal is to encourage child to use words like stock, shares, profit, loss, strategic thinking, opportunity cost and risk. The “Stalk Market” game play provides background knowledge similar to rules of our authentic “Stock Market”. For example, the Stock Market of Singapore operates only on weekdays (i.e., analogous to selling radish only on weekdays) and the prices of the stocks depends on the prevailing current price (i.e., price of radish depends on the specified price on the space token lands on).

Each game sequence step displays the price of radish (e.g. 97 bells, 128 bells, 100 bells, 102 bells) which player can sell if gamer lands on. The opportunity to learn by analogy and mapping the prices of radish to the price of a particular stock and the variability of prices in real life across time depends on supply and demand for the stocks and allows the development and understanding of the dynamic nature of the stock market.

The variability as a whole in “Stalk Market” may result in market crashing or remaining steady as in real life where “Stock Market” may crash or remain steady.

Mastery of the concepts in the Stalk Market will allow learning by analogy of the real Stock Market.

The mediator should then provide many examples and opportunities for the child to use and to become familiar with the words used in Stock Market. Eventually, formative and informal assessment to check whether child could independently use the introduced words in context of activity.
Step 4: Mediation of Transcendence

The goal is to promote the generalization to settings other than the Stock Market, such as in running supermarket businesses involving large inventory, which needs to be maintained with the lowest cost price for maximum profit for selling, or simply deciding what to goods to buy and where to buy that shows sound financial prudence and judgement. Strategic thinking on strategies to maximize profit and to minimize risk may be possible for children with high functioning autism and Asperger Syndrome.

Conclusion

Individuals with autism do not have impairments in systematizing ability, that is, they are able to make sense of natural or artificial constructs that are built logically or naturally based on consistent rules of cause and effect. The digital learning environment provides the ideal environment, as programs written to form the environment are based on computing logic. With adequate time for experimentation, trial and error learning, persistence and perseverance in the digital learning environment based on the liking of the child with autism, mastery of the intended learning of digital game environments with engaged and meaningful learning are certainly possible.

Moreover, purposeful and meaningful play would ignite deep and joyous learning across different learning context (Mraz, Porcelli, & Tyler, 2016). Walz and Deterding (2014) have alluded to a possible gameful world “where games are escaping into everyday life” (p. 2).

With effective mediation and integration of functional curriculum by leveraging or harnessing the acquired background knowledge from the child’s perspective, related new functional knowledge useful to daily life or in academics may be meaningfully learnt.
References


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