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The Effectiveness of Educational Video game on Mathematical Skills Among the Typically developing and Spastic Diplegic Palsy Children – A Pilot Study

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Abstract

Introduction: The visuospatial, fine motor and mathematical skills are correlated to each other. The spatial and maths skills are seen in our daily activities. Training the spatial skill will improve the hand-eye coordination and numeracy of the children. The spastic diplegic cerebral palsy children are delayed in numeracy, fine motor, and spatial skills due to the damage in the brain. These children were consistently low in performance when compared to the typically developed children. The novel Structured Spatial Skills Training Edugame is designed to improve the spatial skills, fine motor skills, and mathematical skills of the typically developing children and atypically developing children. Method: A pilot study was conducted to find the benefits of this novel game. There are four groups, each group have 5 children within the age group 7-14 year. Group A and B comprised spastic diplegic cerebral palsy children and groups C and D comprised of typically developing children, group A and group C received 24 play sessions of video edugame, group B and group D received fine motor training for 24 days (three times in a week for two months). Before and after the training session the spatial skills, fine motor skills, and mathematical skills are measured. Results: The results show that the mathematical skills of the spastic diplegic cerebral palsy children and typically developing children are improved at the end of the play session. Conclusion: This game can be implemented for all slow learners, the child with learning disabilities, Autism, and other conditions which have problems in spatial skills.

Keywords: video games, spatial skills, spastic diplegic, fine motor, maths.

Introduction

Spatial skills

Spatial skills are "skills in representing, transforming, generating, and recalling symbolic, non-linguistic information" (Linn and Petersen 1985), divided skill into three categories. They are spatial perception, spatial visualization, and mental rotation. Spatial perception is the "ability to perceive spatial relationships with respect to the orientation of one's own body in the presence of distracting information" (Cornu et al., 2017). It requires a vertical or horizontal location in addition to a distracting source

(Permatasari et al., 2018). Spatial visualization “involves complicated, multistep manipulations of the spatially presented information, requires analysis of the relationship between different spatial representations, rather than a matching of those representations” (Mohan & Kalaiyarasan, 2019). Mental rotation is "the ability to accurately rotate a two-dimensional shape (2D) or three-dimensional 3D objects in the mind eye to perform a subsequent task (Lowrie et al., 2018). These spatial skills are important in daily activities, occupation, academic achievements. Spatial skills are the core element in STEAM education, Science, Technology, Engineering, Arts, and Mathematics. More studies were done to signify the spatial skills in academic performance and occupation. The results prove that training spatial skills from early childhood is important in later achievements in life.

Mathematical Skills

Kant (1781) from the birth the number concept is one of the priorities which makes the people and even animals to function (Siegler, 2016). The numeracy skills determine the academic performance, the job, analytical skills, survival, and it is seen in day-to-day activities like shopping, paying a bill, finding a bus number, catching a train, booking tickets. “The numerical magnitudes are represented along the mental number line” (Siegler, 2016). The "mental number line" is aligned horizontally with small numbers in left and right has large numbers. Early abilities like counting will have an impact on later numerical problem solving which includes multiplication and division. Arithmetic performance depends on cognitive abilities like "working memory, executive function, and non-verbal intelligence" (Tajadini et al., 2017).

Fine Motor skills

Fine motor involves the use of small muscle of the hand that helps to manipulate things (Tajadini et al., 2017). The active participation and exploration of the children depend upon their motor skills. The locomotion is based on the cognitive skills of organizing spatial information and object permanence. So, "motor skills are the indicator of the cognitive skill development". Fingers have a role in counting, learning arithmetic, and the development of fine motor skills crucially affects the early numeracy of the children. Vision and hand integration should be appropriate to obtain the desired motor output. "Fine motor integration" contributes to the children's academic performance (Carlson et al., 2013). School activities like coloring, drawing, copying, cutting, origami, tracing, shading all require fine motor skills (Marr et al., 2003).

Relation of spatial skills and mathematical skills

The "pure spatial skills have a good foundation in later mathematical skills in the young children" (Cornu et al., 2017). The mental rotation ability of the school-aged children determines the "overall maths ability” of the children (Skagerlund and Traff 2016). Mastering this skill at the age of five determines the mathematical skill at the age of eight (Cornu et al., 2017). Spatial visualization plays an important role in "arithmetic and number line estimation (Zhang and Lin 2015). The spatial skills are related to the mental number line which in turn relates to the mathematical performance (Gunderson et al., 2012). Mathematical achievements and visual-spatial processing contribute to the same brain areas, if there is damage in the parietal lobe, the impairment is seen in both spatial and numerical perception. "An understanding of the numbers and quantities is tied to an understanding of the spatial organization and related movements within the brain structures" since children with high visuospatial skills have good numerical abilities. Mathematical skills, fine motor skills, and spatial skills are related to one another (Carlson et al., 2013).

Relationship of fine motor skills and spatial skills

Frostig, Lefever, & Whittlesey, (1961), visual-motor integration is a part of spatial skills. The "fine motor skills as one of the dimensions needed by the kindergarten children for learning readiness (National Educational Goal Panel, 1993)" (Marr et al., 2003). Visuospatial abilities and have a good association with academic achievements. Visual-motor coordination is the "controlling small finger movements" whereas visual-spatial integration "involves creating a mental representation of an image and replicating it with controlled small muscle movements". These two skills are separate, and both contribute to the children's academic achievements. (Carlson et al., 2013). The relationship between motor skill and maths are seen across the child’s development.

Relation of fine motor skills and mathematical skills

"Visuomotor skills and non-motor spatial skills" both play an important role in the predictors of numeracy in later days. Fine motor skills are seen as predictors of later academic achievements in reading and mathematical performance (Son & Meisels, 2006). This skill "directs cognitive resources towards conceptual processes, such as connecting figures, sounds, understanding mathematical concepts and decoding words" (Becker et al., 2014). Fine motor skill "gives the opportunity to practice mapping visual representation to emerging literacy and mathematical skills" (Cameron et al. 2016). The studies relate that the visual motor skills, reading, and mathematical skill achievement are inter-related (Son & Meisels, 2006).

Effects of Video games

A video game is " a mental contest played with a computer according to rules for amusement, recreation, or winning a stake" (Noemí & Máximo, 2014). It is classified as edugames “designed to develop a skill”, COTS – Commercial off the shelf designed only for entertainment”, exergames – “ physical exercise is accomplished” (Marta Rodriguez Jimenze, Francesca Pulina, 2015). Video games “promote positive attitude towards learning and school, apply knowledge in practice, facilitate trial and error learning process, improves problem solving, and critical thinking skills” (Carissoli et al., 2017). Research was more focused on the effect of video game for “learning, instructions, integration in class-room”. The results showed positive effects and digital games can be used as an alternate and additional mode of teaching and learning (Gong & Piller, 2018). Video games teach “both (Redick & Webster, 2014) formal, informal academic and non-academic skills”. Since the video games are fun, it will increase the motivational level of the children (Alamri, 2016). Playing video game produces improvements in “sensory, perceptual, and spatial cognitive functions, the size of the attention visual field is increased, functional improvement in basic spatial tasks (Spence & Feng, 2010).

Spastic diplegic cerebral palsy children

Spastic diplegic cerebral palsy children have problems in both the side of the body, lower limb more affected than the upper limb. This type of CP is seen in preterm children, the corticospinal tracks and optic radiations are affected (Di Lieto et al., 2021). The children have impaired "non-verbal intelligence, visuoperceptual and visuospatial abilities" (Di Lieto et al., 2021). These children have motor deficits due to the damage in the brain and are associated with various disabilities, that lead to poor academic performance. When compared to the typically developing children, CP children have delayed milestones and as they are slow learners they have difficulty in numeracy. The varying deficits will make the cerebral palsy children less participate in social activities and poor performance in academics. It is mandatory to include the cognitive profile development in the rehabilitation of cerebral palsy children. The present study is focused on how the spatial games are designed to improve the spatial skills, mathematical skills, and fine motor skills of the typically developing children and spastic diplegic cerebral palsy children.

Literature support

The study done by Tom Lowrie (2018), reveals that the spatial training program will enhance the spatial skills of the children. In this study, 337 students were selected from 6 schools, grouped in 15 classrooms, and divided into 8 experimental and 7 control classes. The experimental classes received the Experience-Language-Pictorial-Symbolic-Application framework for about 10 weeks. The control group received the standard mathematical instructions. At the end of the intervention, the experimental groups performed well while comparing the control group (Lowrie et al., 2018). Another study by Sanaz Tajadini et al. 2017, the review of 6 articles out of 74 articles showed that cerebral palsy children have problems in arithmetic performance and fine motor skills. They concluded that the importance of the implication in the educational practices and rehabilitation protocol to increase the manual dexterity of the cerebral palsy children (Tajadini et al., 2017). Laura M. Fernandez-Mendez (2020) studied the role of 'spatial and motor skill in mathematical performance'. 305 children under the age group 6-8 are selected for the study, "A generalized linear regression model with mathematical performance as a dependent variable was performed", the study results suggested that the visuospatial reasoning related to the mathematical performance and it highlights the importance of spatial and motor abilities in maths performance. (Fernández-Méndez et al., 2020).

The purpose of the current study

With the literature background, the structured spatial skills training educational edugame (SSST edugame) was developed. It consists of seven different games, namely maze, puzzle, mental rotation, building blocks, identifying objects, matching shapes, and spatial language. Three different levels, easy, intermediate, and difficult. The child has to play 21 games. Educational video games are finding their way into the pedagogy of teaching and learning. The children are more attracted towards the digital technology, incorporating the technological use in the learning and teaching process will make the learning easy when compared to the traditional way of learning, the access and use of desktop and mobile phones in the classroom were seen in recent years. The spastic cerebral palsy children have a problem in motor and other associated difficulties. Among these, delays in the development of spatial skills, fine motor skills, and maths skills are to be addressed as these are directly related to later academic achievements. Inclusiveness is the other concept whether these children are included in the normal classroom where they can spend and learn along with their normal peer group children. This study will focus on comparing the effects of video games and fine motor training among the typically developing children and spastic diplegic cerebral palsy children.

Materials and methods

The study was conducted after the ethical clearance since it involves human subjects. The informed consent, the child information leaflet, and video game instruction manual were prepared. The spastic diplegic cerebral palsy children and typically developing children were selected for the study. the spastic diplegic children with age group 7-14, both genders, near-normal vision and hearing, good communication, understanding capacity with Manual ability classification system (MAC) level one and two and those who can ambulate independently was selected. On the other hand, the typically developing children who are in elementary grade with normal vision, hearing, communication, and understanding ability were included. The exclusion criteria for cerebral palsy are other variety of CP, problems in hearing and vision, ambulation difficulty, MAC 3-4 and dependent ambulation, and other associated problems like a seizure, mental retardation. The Typically developing children in kindergarten and middle and high school grades are excluded. After selecting the population, they are randomly divided into four groups. Group A and group B comprised of spastic diplegic cerebral palsy children. Groups C and group D are comprised of Typically developing children. the informed consent was read and signed by the parents of the children; they are instructed that they can leave the study at any point of time. After getting the informed consent, a detailed description of how the game had to be played was given to the parents, teachers, and the children. they are also provided with the child information leaflet and SSST edugame instructions manual. The training program was scheduled for two months, three times a week. Before the start of the training, the outcome measure is taken.

Corsi Block test

It assesses non-verbal memory and learning. The test has "non-identical small white cubes (4 x 4 x 4 cm) are arranged irregularly on a small wooden board (26 x 32 cm)". Examiner teaches how to do the test to the children; trial versions are done until the child understands the concept. The child has to repeat the same pattern done by the examiner but in a reverse manner, to assess the backward digit span. The usual test pattern is to start with the two digits and to increase to the long sequence. The test can be ended if the child gives five consecutive wrong sequences. The scoring is done as one score to correct pattern and zero to the wrong pattern. This test assesses the short-term spatial memory of the children. (Orsini, 1994)

Vandenberg and Kuse mental rotation task

The mental rotation of the child is assessed using Vandenberg and Kuse's mental rotation task. It consists of "24 items of three-dimensional images with one reference image on the left and four target images on the right side, the child has to rotate the images mentally to find two figures which match with the target image". One score is given if the child selects two correct images and no score if only one correct image or all both the selected images are wrong (Hoyek et al., 2012).

Beery-Buktenica developmental test for visual-motor integration.

It consists of "copying of series of geometric forms of increasing difficulty". The scoring is based on copying the correct geometric patterns without removing the hand. The standardized score is given with the manual for scoring the test (Findlay et al., 2020).

Westwood the one-minute test of basic number fact (1987)

It assesses numeracy skills, "is a norm-referenced assessment which consists of 33 items in each test of addition, subtraction, multiplication, and division". The child has one minute to complete each test. A score of one is given to all the correct answers and each subtest score is added to get an overall score (O'Rourke et al., 2017).

The structures spatial skills training educational video game

This game is developed on the concept of spatial skills. The video game consists of seven different games, namely maze, puzzle, mental rotation, building blocks, identifying objects, matching shapes, and spatial language. Three levels – easy, intermediate, and difficulty. The games are designed in such a way that the child can play the game by themselves. The motivating factor in the game includes the audio-visual treat, cartoon characters Sai and Sri, a scoring system, and motivational popups. The game is an online game where every child is provided with an individual login id and password. To avoid addiction and over the play of the game, it is pre-programmed in such a way that they can play only for 40 minutes in a day, three days in a week (Monday, Wednesday, and Friday), only for two months, that is after 24 play sessions the game will be automatically locked. The child login, logout time, the game completed, pending games are monitored in the remote server to track the progression of the play for each child.

Fine motor training

It consists of flashcards, the same games played in the video are converted to flash cards. Seven different tasks with three different levels. In the maze, the child has to find the correct way, puzzle – jigsaw puzzle is given with increasing complexity. The mental rotation task, where the child has to mentally rotate the given images to the reference image. Then coloring the block with the same colors given in the reference image. Identifying images of fruits, animals, and birds. Matching shapes consist of shapes and images seen in day-to-day life. Last, identifying the spatial language of the given sentence. The flashcards have to be done for 24 sessions, 30 – 40 minutes in a day, and only on Monday, Wednesday and Friday.

Group A – Spastic diplegic children – play SSST edugame

Group B – Spastic diplegic cerebral palsy children – fine motor training

Group C – Typically developing children – play SSST edugame

Group D – Typically developing children – fine motor training

All the four groups will undergo the training session on Monday, Wednesday, and Friday for two months (24 sessions), 30-40 minutes per day. The outcome measure is taken before and after the training session. The comparison was done between the group and between the training methods.

Results

To test the effect of structured spatial skills educational game and fine motor training in mathematical skill improvement among the spastic diplegic cerebral palsy children and typically developing children. the paired sample t-test was used for each group A, B, C, and D to the test null and alternate hypothesis.

Table 1

Pre-test and post-test values of the group A – paired samples t-test

Variable	Group A					
	Pretest		Post-test			
	Mean	SD	Mean	SD	t-stat	p-value
Backward digit span	1.60	0.55	2.40	0.55	-4.00	0.008
Mental rotation	1.20	0.45	2.00	0.00	-4.00	0.008
Visuomotor integration	0.80	0.84	2.20	1.30	-5.72	0.002
Maths Skills	13.60	3.36	19.40	3.78	-7.89	0.001

In Group A, the mean score of backward digit span increased from 1.60-2.40, the mean score of mental rotation increased from 1.20 to 2.00, the mean score of visual-motor integration increased from 0.80- 2.20, the mean score of maths skill increased from 13.60-15.40, the score is statistically significant (<0.05) after SSST edugame training in the spastic diplegic cerebral palsy children.

Table 2

Pre-test and post-test values of the group B – paired samples t-test

Variable	Group B					
	Pretest		Post-test			
	Mean	SD	Mean	SD	t-stat	p-value
Backward digit span	1.20	0.45	1.40	0.55	-1.00	0.187
Mental rotation	1.00	0.71	1.40	0.55	-1.63	0.089
Visuomotor integration	1.20	0.84	1.20	0.84	-	-
Maths Skills	12.60	3.36	15.40	3.85	-5.72	0.002

In Group B, there is no significant improvement in backward digit span, mental rotation, visual-motor integration after the fine motor training in spastic diplegic cerebral palsy children (>0.05). But the mean score of maths skills increased from 12.60-15.40, which is statistically significant.

Table 3
Pre-test and post-test values of the group C – paired samples t-test

Variable	Group C					
	Pretest		Post-test			
	Mean	SD	Mean	SD	t-stat	p-value
Backward digit span	2.40	0.89	4.00	0.71	-6.53	0.001
Mental rotation	2.00	0.71	3.40	0.55	-5.72	0.002
Visuomotor integration	4.60	2.30	7.40	2.61	-7.48	0.001
Maths Skills	32.30	7.43	43.40	13.24	-4.13	0.007

In Group C, the mean score of backward digit span increased from 2.40-4.00, the mean score of mental rotation increased from 2.00 to 3.40, the mean score of visual-motor integration increased from 4.60 – 7.40, the mean score of maths skill increased from 32.20 – 43.40 the score is statistically significant (<0.05). the SSST edugame training is increasing the skills in the typically developing children.

Table 4
Pre-test and post-test values of the group D – paired samples t-test

Variable	Group D					
	Pretest		Post-test			
	Mean	SD	Mean	SD	t-stat	p-value
Backward digit span	2.40	0.89	2.60	0.55	-1.00	0.187
Mental rotation	2.60	0.55	2.40	0.55	0.53	0.311
Visuomotor integration	4.40	1.14	5.40	1.15	-	-
Maths Skills	29.20	8.35	33.60	6.50	-2.86	0.023

In Group D, there is no significant improvement in backward digit span, mental rotation, visual-motor integration after the fine motor training in typically developing children (>0.05). But the mean score of maths skills increased from 29.20 – 33.60, which is statistically significant.

Table 5
Paired samples t-test – between groups

	Backward digit span		Mental rotation		Visual-motor integration		Maths skills	
Between-group comparison	t-stat	p-value	t-stat	p-value	t-stat	p-value	t-stat	p-value
Group A and B	2.89	0.020	2.45	0.040	1.44	0.187	1.66	0.136
Group C and D	3.50	0.008	2.89	0.20	1.57	0.155	1.49	0.176
Group A and C	-4.00	0.004	-5.72	0.000	-3.99	0.004	-3.90	0.005
Group B and D	-3.46	0.009	-2.89	0.020	-6.64	0.000	-5.39	0.001

Group A and B – Comparing the two treatment SSST edugame and fine motor training effects in the spastic diplegic cerebral palsy children
SSST edugame is statistically significant with the scores of Backward digits span (t = 2.89, p = 0.020 < 0.05), mental rotation (t=2.45, p=0.040 <0.05). the scores Visual motor integration (t = 1.44, p = 0.187 > 0.05), and maths skills (t = 1.66, p = 0.136 > 0.05) says that the SSST edugame is not significantly different from fine motor training in the mean value of visuomotor integration for treatment among the spastic diplegic cerebral palsy children.

Group C and D - Comparing the two treatment SSST edugame and fine motor training effects in the typically developing children
SSST edugame is statistically significant with the scores Backward digits span (t = 3.50, p= 0.008 < 0.05), mental rotation t=2.89, p= 0.020 < 0.05). The scores of Visual motor integration (t = 1.57, p = 0.155 > 0.05), and maths skills (t = 1.49, p = 0.176 > 0.05) shows that the SSST edugame is not significantly different from fine motor training in the mean value of visuomotor integration for treatment among the typically developing children

Group A and C – Comparing the effects of SSST edugame in two sets of the population – spastic diplegic cerebral palsy children

and typically developing children
Typically developing children is significantly better than the spastic diplegic cerebral palsy children after SSST edugame training with the score of Backward digits span ($t = -4.00$, $p = 0.004 < 0.05$), mental rotation ($t = -5.72$, $p = 0.000$, <0.05) visual motor integration ($t = -3.99$, $p = 0.004 <0.05$), and maths skills ($t = -3.90$, $p = 0.005 < 0.05$)

Group B and D - Comparing the effects of fine motor training in two sets of the population – spastic diplegic cerebral palsy children and typically developing children
Typically developing children is significantly better than the spastic diplegic cerebral palsy children after fine motor training with the scores of Backward digits span ($t = -3.46$, $p = 0.009 < 0.005$), mental rotation ($t=-2.89$, $p=0.020$), visual motor integration ($t = -6.64$, $p = 0.000 < 0.05$), and maths skills ($t=-5.39$, $p = 0.001 <0.05$)

Discussions

Maze is a game where the child must find the correct path or way (Hendrawan, 2018). It includes visualizing and mentally tracking the correct path and excluding the wrong path. The visual perception of the entire maze image gives the idea of how to differentiate the paths. The relationships within the objects must be plotted to find the correct way. Jigsaw puzzle, here the images are split into several segments and placed in a disorderly way. the participant must place the split segments in the correct order. This process involves mentally placing the segment in the correct place, so the child needs to perceive the image, then visualize the correct and wrong placement of the split images. It requires visuospatial planning and execution. In Mental rotation, the given image should be matched with the reference image. The game is also provided with a rotation button, which makes it easier to rotate the image to a reference image. The block building is the most interesting game, where the child must drag the shapes to the respective place to make a meaningful picture. This process involves, exact visualization of the object shape, plan to place it in the exact location. Matching shapes and identifying objects involves the identification of the given images to the reference image, for this, the relationship between each image and spatial visualization is needed. Spatial language, guides the play activities, "the spatial categories include (1) spatial location (up, down), (2) deictic terms (here, there), (3) dimensions (long, tall), (4) spatial features or properties (curvy, straight), (5) shapes (rectangle, square), (6), spatial orientations or transformations (turn it around, man is facing the block)". In the SSST edugame, mainly spatial location, deictic items, dimensions, and spatial orientations are used. The spatial language helps the children to play the game even easier. All the games in the SSST edugame are designed to address the spatial skills so that the visuospatial skills can be improved after the training program.

Video games are interactive, provide challenges, goals, feedback, track the progression of the game, preset rules, which makes the children be engaged and reduces frustration in the learning process (Lieberman et al., 2009). The structured game will make the children have active participation in learning and negative aspects like violent behavior will be nullified. "There is an increased recognition of video games as an educational tool or a training technology in various fields like military, educational institutions, and industry" (Choi & Feng, 2016). When comparing the training effects, the backward digital span, mental rotation, visuospatial integration, and maths skills are improved after the training of video games. The SSST edugame contains all the motivation factors like mild sound and colors, cartoon characters Sai and Sri, motivation feedbacks whether it is a win or lose. The game can be played again till the winning of the game. Here the child either spastic diplegic cerebral palsy or typically developing children they both are benefitted in terms of improvement in short term memory (spatial memory), mental rotation, motor coordination, and mathematical skills. The literature says that video games can be used in the classroom environment to enhance the learning process. This helps the concept of inclusiveness where the cerebral palsy children learn along with the typically developing children. The games like this will make learning easier, all three skills are developed simultaneously as they share the same area in the brain. The training of one skill will lead to the improvement in the other skill.

Low mathematical achievements lead to low academic achievements and lead to poor socio-economic status (Duncan et al. 2007). Early mathematical skills are an indicator of later mathematical achievements. the spatial abilities and motor skills play an important role in maths skills attainment (Fernandes et al., 2016). Starting from early childhood to later life positive correlation is seen between spatial skills and maths performance (Delgado et al., 2004). In particular, mental rotation plays an important role in spatial skills (Uttal et al., 2013) and is related to 'arithmetic and mental calculations'. It is a 'cognitive tool 'involved in "mathematical representation where numbers and other elements should be mentally represented and rotated to accomplish various types of mathematical requests" (Cheng & Mix 2014). The spatial and mathematical skills are different but are related to each other (Mix et al., 2016). Visuospatial working memory, visuomotor integration, and perspective thinking are related to each other (Fernández-Méndez et al., 2020) In Primary school children between the age group 4 – 11 years, the study results show that spatial and numerical abilities predict the mathematical skills (Hawes et al., 2019). Interestingly all the groups, irrespective of training and typical or atypical children the maths skills ere improve after the treatment sessions. Both video games and fine motor training will improve the maths skills of the children. Motor skills are "defined as learned sequences of movements that are combined to produce a smooth, efficient action to master an articular task" (Davis et al. 2011). The components of motor proficiency include "fine motor precision, fine motor integration, and manual dexterity" (Bruininks 2005). According to Grissmer et al (2010), fine motor skill predicts the maths specific to "number, shape, size, sequence, addition, subtraction, multiplication and division" (Jasen & Heil 2010).
Due to the direct correlation between spatial skills and mathematical skills, spatial skills training affected mathematical development irrespective of the population and training. Within-group and between-group analysis show that the backward digit span and mental rotation was significantly improved.

Special children have defects in spatial concepts and learning, both are mandatory in academic and like skill. This impact is due to the damage to 'spatial neural structures'. One aspect of spatial skill will affect another aspect, so training of one sphere will enhance the other sphere of the spatial skills. (Akhutina et al., 2003). So the backward digit span and mental rotation are improved after the SSST edugame training, in both Spastic diplegics cerebral palsy children and atypically developed children. Visuomotor integration and maths skills are not significantly developed on SSST video games. But this variable has significantly improved in the fine motor training group. This training will have drawing, tracing, copying which involves hand-eye coordination. Within a group, analysis shows the SSST edugame is statistically significant in both the population and improvement was seen in all the variables. Between the group, analysis shows that the typically developing children are performing more than the spastic diplegic cerebral palsy children.

Conclusion

The Cognitive functions are carried over by the cortex with neuronal networks doing a simple task to complex multiple tasks. These include "perception, attention, memory, motor skills, language, executive functions and visual-spatial processing" (Mohan & Kalaiyarasan, 2019). Each game is specific and requires different cognitive functions some involve just understanding of rules, solving problems, finding a simple way, but some require planning, executive function, multitasking, fast play, good hand-eye coordination.

Table 6
Comparison of games and required cognitive function for SSST edugame.

Cognitive Function	Game
Selection of picture	Puzzle, identifying objects, building blocks
Selection of word	Spatial Language
Switch of picture	Identifying objects, matching shapes
Checking of a correct answer	Mental rotation, spatial language
Spatial cognition	Maze, Puzzles, mental rotation, identifying objects, matching shapes, building blocks, spatial language.
Mental rotation	Mental rotation
Audio-visual feedback	Maze, Puzzles, mental rotation, identifying objects, matching shapes, building blocks, spatial language.
Arousal	Cartoon characters Sai and Sri and feedback after completion of a game
Analysis of correct answer	Mental rotation and spatial language.

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Conflict of interests

The authors declare no conflict of interest.

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