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Effect of game-based activities on executive functioning among pre-school children: Gender as a moderator

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Abstract
This study experimentally investigated the effects of game-based activities on executive functioning of pre-school children with gender as a moderator. A six-week intervention lasting 60 minutes per session was implemented with 120 pre-school children, of ages five to six, using a 2x2 pre-test, post-test, control group design. A multi-stage sampling procedure was adopted for the study. Data were collected using the Executive Skills Questionnaire for Children—Revised ($\alpha = .901$; $\omega = .907$) and analysed using the ANCOVA test at the 0.5 level of significance. Results revealed a significant treatment effect on pre-school children executive function in favour of participants in game-based activity group over those in control group ($F_{(1,75)} = 111.066$; $p < .001$) and two-way treatment and gender effects ($F_{(1,75)} = 2.783$; $p < .05$) but no gender ($F_{(1,75)} = .381$; $p > .05$) and on pre-school children executive functioning was established. It was concluded that game-based activities are effective in enhancing pre-school children executive functioning, and recommended that schools should provide a more conducive environment for pre-school children with different game materials provided to develop their executive functioning skills.

Keywords: Game-based activities, Gender, Executive functioning, Pre-schoolers

Introduction
Preschools, also called nursery or pre-primary schools, are formal educational settings that offer early childhood education to children between the ages of three and five before they enter primary schools. These institutions can be privately owned or operated by the government (Hassan & Sedaf, 2019). It is the cornerstone of the Nigerian educational system and the beginning of a child's growth. Preschool is a period of broad psychological development during which many of the skills that will be developed further into young adulthood are first expressed (Brown & Jernigan, 2013). Likewise, this is a stage of rapid brain development, and the key to networking the brain cells in children, by providing unsurpassed stimulation at the appropriate time. These brain cells shape the way people behave, think and learn throughout their lives (Cecil et al., 2020). The diverse functions of the brain perform in different ways, which leads to acquiring skills and abilities in all developmental areas. One area of child brain development that needs to be critically examined is the executive functioning skills (Knapp & Morton, 2013).

Executive function is a collection of cognitive abilities that support time management, attention to detail, switching between tasks, planning and organisation, avoiding mistakes, acting on experience, and multitasking (Gündüz, 2017),. It is a set of skills that is controlled by a part of the brain known as the frontal lobe, which is responsible for intellectual skills like working memory, self-regulation, and mental flexibility. All these skills continue to develop and mature throughout childhood to the teen years, and even adulthood. To make sure that children acquire these skills, it is important to know how the quality of interconnection and experiences of their immediate environment either weaken or strengthen these growing skills (Hofmann et al., 2012).

Executive function skills serve as the traffic controller of the brain towards helping children stay focused, plan ahead and set goals, regulate emotions, and so on (Center on the Developing Child, 2019). They are abilities needed to

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function well in life. However, as important as these skills are, it has been discovered that some children have low executive function skills. Studies have revealed that low executive function skills in children could be caused by a number of factors which include early childhood stress either from home or at school (Calderon, 2020), such as tension at home, separation of parents, domestic abuse, as well as stress of teaching and learning, making friends, abusive care giver and so on (Stachel, 2015). Therefore, there is the need to look for a way to ease this tension in children and as such improve their executive function skills.

Research has revealed that games are loved by children and has proven to be an important source of learning. One of these researches was carried out by Al-Tarawneh (2016) who investigated the effectiveness of educational games on scientific concepts acquisition by the first-grade children, with eight educational games, and a test to measure scientific concepts acquisition. The study recommended using educational games in teaching science in primary education. Games reduce tension, clears boredom, and promotes an environment where teaching and learning is enjoyable, interesting, thrilling, motivating, and academically rewarding (Cheung & Ng, 2021). Children who engage in games are able to interact with other children and build their own world of imagination and happiness.

Games play an important role in teaching children. Using games when teaching children makes them to be diligently involved in everyday lessons since it gets their attention, while they are interested in learning a game (Adipat et al., 2021). Plass et al. (2015) claim that using games in the classroom can encourage pupils to take chances, improve interaction among pupils, and foster social and emotional learning. The well-known multiple-choice quiz game 'Kahoot' was found to have a positive impact on pupils' mindsets towards learning and to raise their academic scores in a research by Fuster-Guillo et al. (2019). Virtual games have also been shown in tests to aid children with Attention Deficit Hyperactivity Disorder (ADHD) focus and pay attention, as well as assist pupils with dyslexia with their spatial and attention problems, which can improve their reading. Given the rapid advancement of technology in today's world, it is not surprising that instructional games are being used in classrooms increasingly and frequently. A fun and interactive approach for pupils to pick up new knowledge and abilities is through games. An enjoyable diversion from conventional classroom teaching techniques is provided via games (Gungor, 2022).

Because games increase the desire of children to learn, their level of engagement, and their focus, integrating games into the classroom is generally more effective than using standard teaching approaches. Furthermore, games help children become more socially adept and develop their problem-solving and comprehension skills. Numerous science-related academic topics employ game-based learning, sometimes referred to as game-based activities. In a nutrition lesson, Yien et al. (2011) discovered that using game-based learning improved the education of children's results more than traditional teaching methods and even changed their eating habits. According to Ezeoguine and Augustine (2021), learning through games increased children's engagement and active learning in science, and the lessons they learnt had a more profound effect than those taught through traditional techniques.

Game-based learning helps to solve educational problems at all levels. The majority of research on game-based learning, however, was done at the secondary school level and used games in conjunction with other strategies, like game and simulation, game and analogy, or two different games, like card-and-geoboard-based games or ladder-and-tunnel games, to find the most successful approach. A study carried out by Vlachopoulos and Makri, (2017) is one of such studies, which investigated the effect of games and simulations on higher education. The study revealed that games and simulations have a positive impact on learning goals. Another of such studies by Kapp (2018) investigated the effect of board games and card games in enhancing learning experiences. The study concluded that the use of board games and card games should be considered when creating

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meaningful learning experiences. Children learn a lot from games and have better cognitive development as a result.

Certain interventions, including those based around computer training, martial arts, physical exercise, and meditation, have been noted to potentially aid in the development of executive functions (Diamond & Lee, 2011). The term "cognitive games" refers to a collection of several games that are intended to enhance cognitive abilities and are utilised for training and intervention (Ramos, 2019). Because they encourage training in a secure environment and can provide learning that extends beyond the game itself, games, according to their features, aid in the development of executive functions.

Research shows that assessing how children's use of digital games affects their executive processes (Diamond & Lee, 2011), flexibility and reasoning, and working memory and attention (Rueda et al., 2012). Rueda et al. (2012) conducted a study that included 37 5-year-old children who were separated into two groups based on relevant research. While the control group did not take part in any intervention sessions, the first group received ten sessions of computerised attention training. Children's performance on a range of tasks, including attention, intelligence, and attachment management, was evaluated before, throughout, and two months following the conclusion of training.

According to the findings of a study conducted by Rueda et al. (2012), the trained group's children activated their executive care network more quickly and effectively than the untrained children. Rosas et al.'s 2019 study looked at the impact of games on the development of Executive Function (EF) in young children. Thirty-two games in all were meant to be played in groups by the entire class of seventy kids. The games were specifically designed to enhance three areas of executive function: working memory, inhibition, and cognitive flexibility. EFs were assessed using three different methods: prior to the intervention (TI), immediately following its conclusion (T2), and eight months later (T3). The results reveal a significant difference ($p = 0.04$) in the EF development between TI and T3 between the experimental and control groups. Additionally, a substantial correlation between Mathematics performance at T3 and EFs evaluation at TI was seen in the results.

Gender is used as a moderating variable in this study because one would start to ask if games have the same effect on children' executive function skills regardless of their gender. Gender is the social trait and possibilities associated with being female or male and the relationship between women and men, girls and boy, as well as the relation between them. The relationship between gender and social skills during development is complex. The most effective results show that in early childhood, boys prefer social play with physical activities, whereas girls prefer more passive, sedentary activities (Merrell & Gimpel, 2014). Gender differences usually manifest among children, especially in play and play choices. Regardless of age, males tend to spend more time in physical activities, while females tend to exhibit better self-care skills than males (Hands et al., 2016).

In India, Baruah and Rani (2021) conducted research on children's executive function skills in connection to gender. The objective of the study was to investigate how male and female youngsters differ in terms of executive skills such as behavioural regulation, organisation, emotional regulation, time management, and plan management. A sample of forty children from The Indian School of Bahrain, aged between eight and thirteen, were included in the study. There were twenty male and twenty female children. The Strait et al. (2020) developed the Executive Skills Questionnaire-Revised to assess the individuals' proficiency in executive functions. From the findings of the study, it may be established that The Indian School of Bahrain male and female children did not significantly differ in their level of Executive Function skills. The findings also suggest that the few skills of children of their strengths and few skills they need to work on.

In connection to games, Ramos et al. (2019) investigated the relationship between gender

ISSN: 2714-2965 (Print)
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and games and executive function, with an intention to assess how children's executive function develops when they play games in a classroom. In order to investigate the usage of cognitive games in small groups, they employed a qualitative and quantitative approach based on organised interventions. The outcomes showed that working memory, processing speed, and attention had all improved regardless of their gender. While the outcomes cannot be solely attributed to the intervention, it does suggest that moderate and intentional game use can improve executive functioning.

This study's goal is to examine, with gender acting as a moderator, the impact of game-based exercise on pre-school children's executive functioning. The following hypotheses were put forth:

i. Game-based exercise has no discernible major effect on the executive functioning of pre-school children.
ii. Gender has no discernible primary influence on the executive functioning of pre-school children.
iii. Game-based exercise and gender do not significantly affect the executive functioning of pre-school children in a two-way manner.

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METHODOLOGY

This research employed a quasi-experimental approach using a 2 x 2 factorial matrix experimental study design with pre-, post-, and control group components. Treatments considered at two levels - the game-based group and control group while gender was also considered at two levels - male and female. The justification for the factorial design is that it allows for testing the variables at main and interaction level.

All children enrolled in the one-year mandatory pre-school programme, which comes before Primary One in public and private primary schools in Ogun East Senatorial District, Ogun State, Nigeria, between the ages of five and six, comprise the study's population.

A sample of 120 pre-school children were randomly selected and used in the study. The pre-school children were five to six years old and went to both public and private schools. A multi-stage sampling strategy was employed for the inquiry. Six local government areas were chosen at the first stage from among the nine Local Government Areas in Ogun State's Ogun East Senatorial Districts using a random selection technique. To make a total of two schools from each Local Government Area, one public and one private pre-school were randomly selected from each of the six Local Government Areas. There were 120 children in all, with ten pre-school children selected from each school. Second, public primary schools that offered pre-school classes were also randomly chosen, as were privately owned, government-approved, and registered pre-schools. These were chosen from among the Local Government Areas that were chosen. The experimental and control groups were distributed at random among the schools.

The revised version of the Executive Skills Questionnaire for Children (pre-school and kindergarten) was used. The rating system was developed by Dawson and Guare (2010). The scale was designed to evaluate children's executive skills in order to identify their unique strengths and weaknesses. It consists of 11 skill areas that seem to represent distinct and separate executive skill domains. The questionnaire has separate rating scales for each age group; however, the preschool/kindergarten version of the questionnaire was used for the purpose of this study. For the purpose of this study, instructors from the schools visited filled out a questionnaire that indicated each pre-school child's strengths and weaknesses in executive skills based on how well it described every child in their class. The children in the schools that were visited were also exposed to different type of games. ESQ-R demonstrated excellent internal consistency of $\alpha = .901$ and $\omega = .907$ (Hira, 2021).

Procedure

The study was carried out in three phases:

Phase One: Pre-treatment

This entails choosing the participants and dividing them into control and treatment groups.

ISSN: 2714-2965 (Print)
ISSN: 2714-3449 (Online)

The research instrument was given to instructors of the pre-school children in the sampled classrooms of the schools. Therefore, based on their score from the questionnaire filled by the instructors, participants would be rated low and high respectively. Participants perceived to have low executive function skills according to the outcome of the pre-test were selected. Ten children each were randomly sampled from the 12 preschools visited in the six Local Government used for this study. The children from the schools were randomly assigned into treatments and a control group.

Phase Two: Treatment

Over the course of six weeks, the participants received treatment packages that focused on game-based activities for the children in the treatment group. The class teachers in the sampled classes were trained as research assistants before the administration of the treatment package. Participants in the control group learnt the fundamentals of reading only through exposure to reading skills. They were not exposed to the different game-based activities like the children in the treatment group.

Phase Three: Post Treatment

In order to assess the efficacy of the treatment plan, the participants in the two groups—the game-based activity group and the control group—were given the instrument once more at the eighth week.

RESULTS

Hypothesis One:

Game-based exercise has no discernible major effect on the executive functioning of pre-school children .

Analysis of Covariance of Treatment and Gender Effects on Executive Functioning

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5889.50	4	1472.37	53.01	.00	.74
Intercept	2144.90	1	2144.90	77.22	.00	.51
PretestExec	4805.01	1	4805.01	172.99	.00	.70
Treatment	3085.05	1	3085.05	111.07	.00	.60
Gender	10.59	1	10.59	.38	.54	.01
Treatment * Gender	77.31	1	77.31	2.78	.01	.04
Error	2083.25	75	27.78			
Total	435754.00	80				
Corrected Total	7972.75	79				

The results in Table 1 showed that pre-school children's executive functioning is significantly affected by the therapy ($F_{(1, 75)} = 111.07$; $p < .001$). There was no discernible gender effect ($F_{(1, 75)} = .38$; $p > .05$). Furthermore, a gender and treatment interaction effect on executive functioning was noted ($F_{(1,75)} = 2.78$; $p < .05$).

Table 2:
Descriptive statistics of Executive Functioning by Treatment

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Game-Based play	80.06	.88	78.31	81.81
Control	66.36	.88	64.61	68.11

In Table 2, results showed that participants in the game-based activity group had a mean score of 80.06 and a standard error of .88. In contrast, those in the control group had a mean score of 66.36 and a standard error of .88.

ISSN: 2714-2965 (Print)
ISSN: 2714-3449 (Online)

Table 3:
Post-hoc Analysis of Treatment effect on Executive functioning

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Game-Based play	Control	13.70*	1.30	.00	11.11	16.30
Control	Game-Based play	-13.70*	1.30	.00	-16.30	-11.11

Results in Table 3 indicated that participants in game-based activity group had significant executive functioning over participants in the control group (MD = 13.70; Std Error = 1.30; $p <$. 001). This result is graphically presented in Figure 1.

Figure 1: **Chart of Treatment Effect on Executive Functioning.**

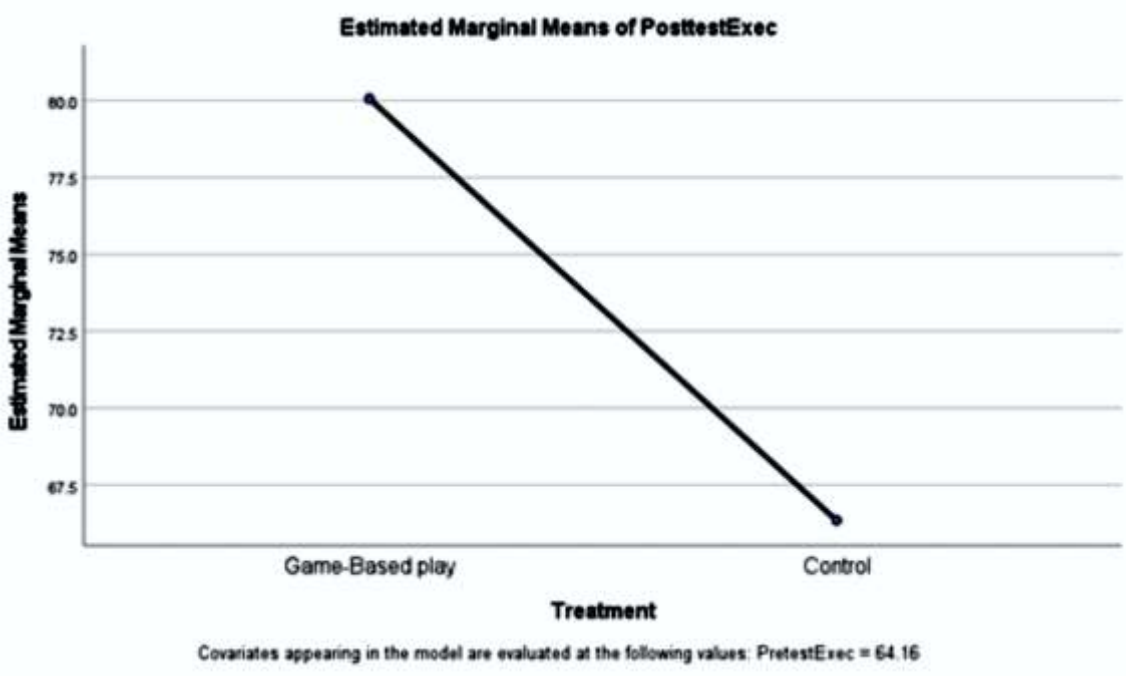

Chart in Figure 1 showed that participants in game-based activity group are higher in executive functioning than participants in the control group.

Hypothesis Two:
Gender has no discernible primary influence on the executive functioning of pre-school children.

Table 4:
Descriptive statistics of Executive Functioning by Gender.

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	73.58	.85	71.89	75.26
Female	72.84	.83	71.19	74.49

ISSN: 2714-2965 (Print)
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Results in Table 4 showed that male participants had a mean executive functioning score of 73.58 and standard error of .85 as against the mean score of 72.84 and standard error of .83 recovered by female participants.

Hypothesis Three:
Game-based exercise and gender do not significantly affect the executive functioning of pre-school children in a two-way manner.

Table 5:
Descriptive Statistics of Executive Functioning by Treatment and Gender.

Treatment	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Game-Based play	Male	81.42[a]	1.27	78.88	83.95
	Female	78.70[a]	1.15	76.41	81.00
Control	Male	65.73[a]	1.16	63.42	68.05
	Female	66.98[a]	1.27	64.46	69.50

a. Covariates appearing in the model are evaluated at the following values: Pretest Exec = 64.16.

Results in Table 5 showed that, compared to male participants in the control group who recorded a mean score of 65.73 and a standard error of 1.16, male participants in the game-based activity group had a mean score of 81.42 and a standard error of 1.27. In contrast, female participants in the control group had a mean score of 66.98 and a standard error of 1.27, while those in the game-based activity group had a mean score of 78.70 and a standard error of 1.15. The hypothesis which stated that game-based exercise and gender do not significantly affect the executive functioning of pre-school children in a two-way manner was not accepted by the finding of this study. This result is graphically presented in Figure 2.

Figure 2: **Chart of Treatment and Gender Interaction Effect on Executive Functioning.**

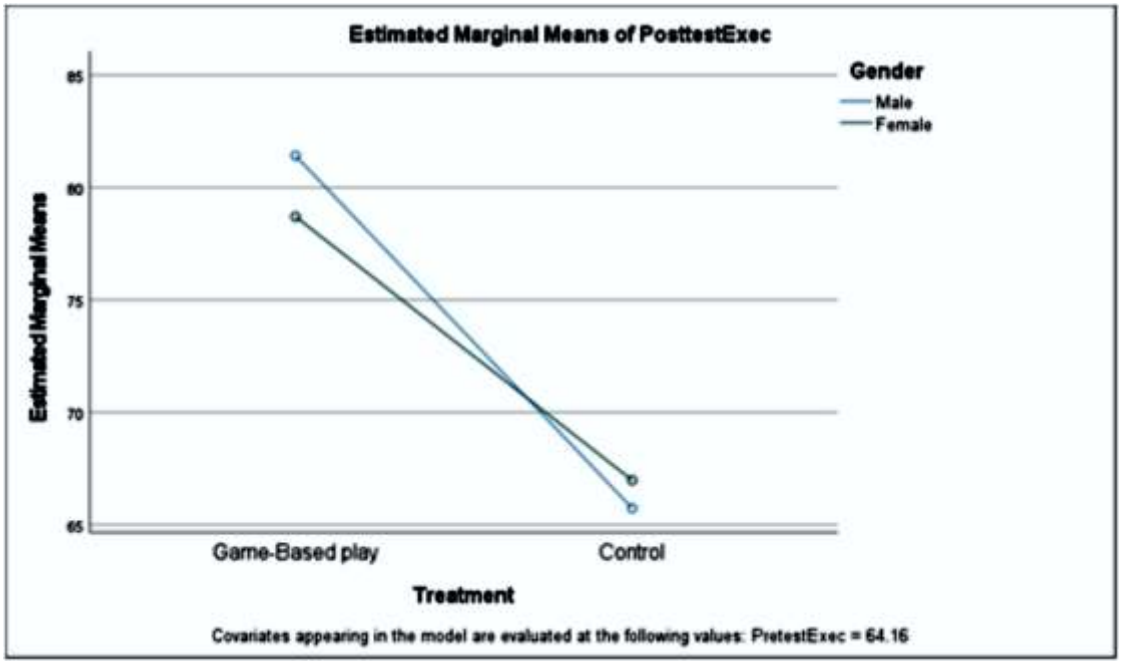

Chart in Figure 2 showed that male participants in the game-based play intervention group had a mean higher executive functioning score than the female participants, in the case of the control group, female participants had higher score on executive functioning score.

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ISSN: 2714-3449 (Online)

Discussion

This study investigated the effect of game-based activities on executive functioning among pre-school children, using gender as a moderator. The study's findings demonstrated that the treatment has a major impact on the executive functioning of pre-school children . In other words, the treatment, which is game-based activities worked significantly on the executive functioning of pre-school children. This finding supports the result of Rueda et al. (2012), who shared 37 5-year-old study participants into two groups—the treatment group receiving ten sessions of computerised game training, and the control group not receiving any intervention sessions. Children's performance on a range of tasks including attention, intelligence, and attachment management, was evaluated before, throughout, and two months following the conclusion of training. The results showed that children in the treatment group activated the executive care network more quickly and efficiently than those in the untrained group.

The outcome of this study is not surprising as it corroborates the results of Rosas et al.'s (2019) investigation into the effects of games on pre-school children' executive function (EF) development. Thirty-two games in all were meant to be played in groups by the entire class of seventy children. The games were specifically designed to enhance three areas of executive function: cognitive flexibility, inhibition, and working memory. EFs were assessed using three different methods: prior to the intervention (TI), immediately following its conclusion (T2), and eight months later (T3). The findings show that the EF development between TI and T3 in the experimental and control groups differed significantly ($p = 0.04$). Additionally, a substantial correlation between Mathematics performance at T3 and EFs evaluation at TI was observed in the results.

This study also revealed that gender has no discernible impact on pre-school children's executive function. This supports the results of a study conducted in India by Baruah and Rani (2021), with an objective to establish how male and female youngsters differ in terms of executive skills such as behavioural regulation, organisation, emotional regulation, time management, and plan management. The results of the study led to the conclusion that male and female pupils at The Indian School of Bahrain did not significantly differ in their executive function abilities.

Additionally, this study revealed that gender and treatment intervention had discernible effects on pre-school children's executive function. Whereas male participants in the game-based play intervention group had a mean higher executive functioning score than the female participants, in the case of the control group, female participants had higher score on executive functioning. This demonstrated that the treatment, which consists of gender-specific game-based activities, has appreciable impact on pre-school children's executive functioning. In other words, game-based play intervention worked significantly better on the executive functioning for male pre-school children than it did for females. By implication, efforts to improve on the executive functioning of male pre-school children can adopt game-based play activities intervention.

Conclusion

The study's results indicate that game-based activities have a considerable positive impact on pre-school children's executive functioning. It also showed that gender has no significant moderating effect on the executive functioning of pre-school children . Game-based activities and gender was also revealed not to have a significant effect on the executive functioning of pre-school children on a two-way manner. In other words, the outcome of this study revealed that game-based activities have a significant impact on pre-school children's executive functioning regardless of their gender.

Recommendation

The study's conclusions demonstrated the beneficial impacts of game-based activities on pre-school children's executive functioning. Based on this, the following recommendations are made:

1. More research on game-based interventions is recommended, as this could have great effects on

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the cognitive and social development of the children, most especially the pre-school children.

2. Schools should provide a more conducive environment for pre-school children and provide different game materials for children to develop their executive functioning skills. It is recommended that educators and carers receive training on incorporating game-based activities into their lessons in order to support pre-school children's improvement in executive functioning.

3. Policy makers are encouraged to include games into the curriculum of the pre-schools, and ensure that teachers use this as part of inculcating knowledge in the children.
4. Authors and publishers of children textbooks are encouraged to incorporate game-based activities in the children's books, rather than just reading and writing activities.

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