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RESEARCH ARTICLE

Effects of Game-Based Learning on Enhancing Abstract Thinking in Children with Autism Saudi Students

Dr. Mohamad Ahmad Saleem Khasawneh*

Special Education Department, King Khalid University, Saudi Arabia

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***Corresponding Author:**

mkhasawneh@kku.edu.sa

ABSTRACT

The present research focuses on the effectiveness of game-based learning in the improvement of abstract thinking ability children with autism in relation to conventional teaching methods. As the study was quantitative, the design of the three groups was a controlled intervention whereby assessments were taken before and after the intervention to assess the cognitive gains of the participants. More so, when students were involved in the game-based learning activities, their abstract thinking skills improved immensely as opposed to the non-intervention group that was taught through usual approaches. The paired t-tests and independent t-tests were conducted to compare the group means and indicated very significant differences between the two groups and on a larger scale, with the intervention group seemed to exhibit a greater gain. It also brought out the issue of maintenance of the gains that were noted together with the need to understand how children with RTIs learn to make appropriate educational recommendations. These results therefore serve to support the idea of the use of such strategies as form of education in the physical development of children with autism. The findings add to the existing literature on the use of games to teach children with autism and with LDs in educational intervention.

INTRODUCTION

It represents a highly important component of the cognitive development that has massive impacts on learning, problem-solving and functioning. In autism, abnormalities in concrete thinking are exemplified by the choice and understanding of ideas and information that are not easily reduced to tangible representations hence leading to poor academic performance and socialization (Alston, 2021). Subsequently, while effective educational approaches continue to change, there is increased awareness about possibly new forms of intercessions that would improve abstract thinking ability in learners with autism. This is one intervention that has received considerable interest and has been defined as 'game-based learning' which entails the use of interactive and fun approaches to learning to foster cognition.

Studies conducted in the last few years have brought to light what gamification can offer in terms of cognitive education across different domains, given the contextualized learning settings that are usually in a game.

Engaging games may benefit children with autism in particular since the use of visual, auditory, and tactile display elements in the garb of a Game is structured and fun while being potentially helpful in the development of higher order abstractions (Klopfer, 2008).

It has also been found that game based learning has a positive impact on working memory, cognitive flexibility and problem solving strategies which forms part and parcel of abstract thinking. For instance, in their study, Peralbo-Uzquiano et al. (2020) noted that learning through games improves cognition; a valuable benefit to the learning process of a child with autism since such a child may take

more time to grasp formal concepts than a typical learner. Due to an inherent possibility of repeated practice and instant feedback which is inherent in game-based learning these children are given a favorable learning environment.

Still, as the present study suggests, there are some advantages of prescribing game-based learning strategies for children with ASD: There is, nevertheless, a significant gap in the existing literature on the effects of game-based learning for development of abstract-thinking skills in children with autism. Chou et al. (2023) state that, in regard to general cognition and behaviour, extensive research has been conducted on game-based learning but few have focused on the effects of game-based learning on abstract thinking. This gap is even more important as abstract thinking is one of the areas that were identified to be problematic in children with ASD and there is potential for considerable gains in cognitive /Functional Forex (Pasqualotto et al., 2021).

Relative to Saudi Arabia, this study is particularly valuable. In their study, Mohiuddin et al. (2023) identify that there has been a shift toward including different aspects of contemporary practices and innovations in Saudi context of education. However, more specific and localized studies on the matters relating to autism and influencing intervention in Saudi are rare (Alghamdi, 2018). Studying the impact of the game-based learning within this context of cultural and educational setting is imperative to foster culturally sensitive reformative learning model that can meet the needs of Saudi children with such a disability.

That is why it is crucial to focus on the key cognitive input – the development of higher-level abstraction abilities. According to Reeve & Cheon (2021), development of abstract thinking leads to the enhancement of academic achievements, problem solving skills and increased level of autonomy of individuals in their daily practices. These outcomes are important for the children to have the best outcome possible with autism and enable them fit into the society better. As for such children experiencing such unique forms of learning difficulty the possibility of enhancing cognitive achievement via game based learning is clearly an interest area.

Problem of the Study

One of the most important noted difficulties of children with autism is the existing problem with the abstract thinking, that lead to the problems in problem-solving and using of the concepts. There is also need to comprehend objects, things, and ideas that cannot be seen, touched or otherwise manipulated, which is fundamental to learning and general functioning. Children on the autism spectrum have indeed difficulties in learning these fundamental cognitive skills and it might be attributed to the fact that traditional approaches may not fully facilitate the learning needs of such children. While, an increase in concern has observed in Saudi Arabia regarding implementing the modern practices and technology in education, however, limited attention is paid to the use of effective interventions for the improvement of abstract thinking skills among Saudi learners.

Another successful learning technique that has being practiced for some time now is the game based learning that comprises of abstract thinking skills, addition to the fact that it offers learning activities in form of games. There is also a lack of information concerning the effects of using games for learning on the ability of children with ASD to think abstractly, in Saudi Arabia included. This research aims to fill this gap through the following research question: If there is any, to what extent does game-based learning enhance abstract thinking skills among Saudi children with autism? Knowledge of how effective this approach might be could go a long way toward improving the kind of education provided to these children in the hope of observed improvements in their cognitive abilities.

Research questions

1. How does game-based learning impact the development of abstract thinking skills in children with autism?
2. What are the specific cognitive benefits of game-based learning for children with autism in the context of Saudi Arabia?
3. How do the outcomes of game-based learning interventions compare to traditional educational methods in enhancing abstract thinking skills in children with autism?

Significance of the study

The importance of this study is found in the probable contribution it can afford on the educational purposes meant for autistic children. Confining its subject to game-based learning the study looks into a still rather under-researched approach that might be helpful to improve such students' cognition on the account of the difficulties they face. If game-based learning is going to be effective, it can present a more enjoyable and interactive manner of developing and improving Abstract Thinking abilities, which are necessary for learning and for basic functioning. Moreover, this study has significance on the educational setting in Saudi Arabia. With the gradual progression of the kingdom in implementing most of the recent technological and educational innovations, it becomes pertinent to develop local studies that focus on the disability's prevalence among Saudi kids. The results could help to design specific culturally accommodating approaches to education and would thus fit into the existing knowledge on optimizing the method of delivering educational content through games to cultural/educational environments. In conclusion, the study is intended to narrow the gap between new educational approaches and the children with ASD in order to provide real-world recommendations to educators, policymakers and parents. Therefore, through offering proof about the efficiency of the game-based learning, the study might have the potential to influence subsequent learning approaches and thus, assist in enhancing the learning benefits of the children with autism in Saudi Arabia and in other nations.

Terms of the study

Game centred learning is defined as use of games, sims or activities to teach and develop young minds and their abilities. As for the concept of game-based learning in this study, it refers to digital and non-digital games with the capacity of maintaining the learner, the child with ASD, engaged in activities with an aim of encouraging abstractness and problem solving. On the part of abstract thinking, it has been described as the degree of thinking that is used to reason through propositions that cannot be experienced or touched, ideas as well as hypothesizes. It is formulated within this study as an ability for concrete thinking including the ability to grasp ideas, reason, and use experience to solve problems. The term "Children with autism" is used to address children who are diagnosed with autism spectrum disorder, which usually manifest in developmental and social skills, communication, and sensitivity to sensory stimuli, as well as exhibit unrelenting and recurrent patterns of behaviour. The research is more precisely aimed at Saudi children falling within this diagnostic group, with reference to their learning and development.

Limitations of the study

Some limitations include: First of all, the sample size and the criteria of sample selection may affect the generality of the conclusions. This study involved only Saudi children with ASD, hence may not reflect other children with ASD in other cultural or geographical settings. Second, because changes in cognitive processes were measured only pre and post-test the investigation might not have captured all the cognitive changes, and may not reflect the comprehensive effects of the game-based learning intervention. As beneficial these measures are, they do not consider variances in learning development rate or the long-lasting effects of the intercession. Furthermore, the results of the study may be also affected by the individual design and practice of the game-based learning programme employed. The changes in the quality, content, and presentation of the game may impact the results and the findings cannot be generalized to other game-based learning interventions or to other learning environments. Last but not least, influence from explicit variables of the participants' home environment, involvement of parents, as well as any other concurrent treatment can affect the findings of the study. Such factors could impact the consistency of the resultant effects; thus they should be taken into account while doing a synthesis of the results and making suggestions for the subsequent studies.

LITERATURE REVIEW AND PREVIOUS STUDIES

Abstract thinking is the capacity to process information that is beyond the range of visible conception and it plays an important role in different spectra of the individual's functioning and learning processes (Alenezi, 2023). One's understanding of the concept of abstractness is crucial for the

capacity to study and possess practical problem-solving skills, and children with the ASD have a rather poor understanding of these components of the cognition process (Bruno et al., 2024). These difficulties are connected with the basic symptoms of ASD, including troubles with social communication and the presence of stereotyped, repetitive behaviors, which may impact working memory and executive functions, including cognitive flexibility and problem solving (Lingala et al., 2021). For example, Macoun et al. (2021) stated that autistic children may encounter difficulties with tasks involving the application of the mental manipulations on abstract functions which inhibit their capacity to transfer learning to different areas.

Gamification of learning has therefore emerged as a popular, novel pedagogical model that focuses on the use of games in the development of learner's thinking processes. Videnovik et al. (2020) while giving his perspective stated that games foster learning by offering rich context, as well as providing the learning path through the repeated practice. This approach corresponds to the constructivist theory of Zhang & Yu (2021) on personality and the outcome of social interactive process that necessitates activity to achieve an objective. The key attribute of both learning games and independent learning is that they allow practice numerous times with feedback; this unites and consolidates abstract thought repertoires as needed.

Other pieces of scholarly work by Johann & Karbach (2020) and Peralbo-Uzquiano et al., (2020) show that application of game-based learning increases one's higher order functions together with the control processes including the working memory and cognitive flexibility. These are important for abstract thinking and these are the academic domains which are likely to be problematic for children with autism. For instance, Papastergiou's study showed that use of DGBL can improve learners' problem-solving skills and motivation; this may benefit children with autism because they require more stimulating ways of learning.

Even though the general application of game-based learning has received increased attention in recent years, the effects of the application on abstract reasoning in children on the autism spectrum has not been well researched. Gallud et al. (2023) made a synthesis of a literature about game-based learning for children with autism resulting in the conclusion about positive impact on both global cognition and behavior. However, the review made some suggestions in regard to possible directions for further research pointing to the necessity to provide more concentration on the investigation of definite cognitive areas, for instance, abstract thinking. Fewer very extensive works exist in this sphere, which proves the need for the investigation of how game-based learning could help children with autism meet several challenges they have.

Gashaj et al. (2021) studied the impact of using Games on AS children and noted that the performance in executive functions increased, these being in relation to abstract thinking. They found the prospect of using games for increasing mental abilities in a general sense as supported by their work but also called for more precise research to determine the effect on the students' ability to abstract. The result indicates that game-based learning causes the positive effect, however, the studies on how far it influences on abstract thinking is needed more specifically.

In the Saudi context, the application of advance technologies in education especially the game – based learning has been viewed as a part of the recent educational reforms. However, more discrete research about autism spectrum disorders focused intercessions is still lacking. Conducting culturally appropriate research becomes a matter of importance to fill the gap that hampers the support of Saudi children with an ASD. The absence of such research underlines the significance of the present work in adding up beneficial findings toward the debatable subject of the utilisation and assessment of games for learning within the context of Saudi system.

Thus, the present research contributes to the existing literature in several ways regarding the application of game-based learning. More specifically, more research is required that aims at improving the abstract thought processes in children with autism; most interventions have for example looked at general cognitive and behavioral results (Hajri et al., 2022). Also, some of the factors that affect the outcome of game-based learning are the type of games to be used, the number of times a learner is exposed to the games and the duration of those exposures and; the type of learners (Ding & Yu, 2024). Closing these gaps through conduct of focused research could therefore

yield a better insight of how game-based learning might be tailored towards enhancing the learning ability of children with autism.

METHODS

The study design adopted in the study was the randomized controlled trial (RCT) to analyze the impact of using games in the improvement of abstract thinking skills in Saudi children diagnosed with ASD. This design was favored for it can determine cause effect by relating the evaluation of the interventional group to that of a control group. The subjects of the study were divided into experimental and control groups due to the method of random selection program, where the first group worked with the game-based learning program, and the second group was made to utilize conventional methods of learning. Random assignment reduces selection bias and made it possible to compare outcomes that could be as a result of the intervention with those that were the result of initial difference in the two groups.

Participants

Some considered subjects were included; children between the age of 6 to 12 years with diagnosed ASD. Entry criteria used in this trial included a clear diagnosis of ASD, capability to attend the intervention, as well as parental permission. Extremely mentally or physically disabled children, who could apply limitations to their involvement in the sample were omitted in order to evaluate a benefit of the intervention. To accommodate issues of internal validity, subjects were selected through stratified random sampling in a way that would enable the identification of the, degrees of the severity of autism, gender and age of the subjects in order to eliminate possible confounding factors, this in turn would help to increase external validity.

Intervention

The intervention was an exceptionally well-planned game-based learning program for practicing abstract thinking whereby it was targeted on learners with ASD. This program was piloted over a 12-week period and involved the subjects attending at least two weekly sessions. The structure and the nature of intervention that was proposed and applied were evidently distinctly different from the educational need's intervention aimed at the participants' cognition, which the rest group received.

Game design

The focus of the intervention implemented was the creation of games which would be designed to address abstract thinking and numerical computations. Some of these games were basically a set of tasks and activities that have to be completed with the purpose to stimulate and work on the abstract thinking part of the players. Games included tasks in which people were to find and continue realised sequences or patterns; in other words, people were expected to grasp abstract relations of various objects. The program consisted of activities such as brainteasers, wherein the subjects needed to engage problem solving applying abstract ideas. For example, manipulatives could include puzzles, fitting together of individual pieces to a whole picture or logical problems that had no readily available solutions. Some of the games involved situations where an actualistic scenario was presented, and the participants were required to utilize abstract reflections to complete the set goals. These tasks were created with the intention of enhancing challenge and fluency and to generalize skills learnt in the class.

It was done through face-to-face and computer aided game-based learning sessions in both soft and hard copy. Television programmes were used, which involved the use of computer-based games to pose abstract thinking task to the children with the engagement of interfaces. Some of these activities were synergistic and employed the use of visual or audible feedback so as to enhance the concentration and interest of the participants. Other teaching aids such as board games and other tangible teaching and learning aids were also used to facilitate a tangible learning experience. These games had physical aspects such as cards, tokens and boards which made direct interactions and manipulations of the ideas involved.

Every session took about 45 minutes and it was facilitated by teachers or therapists who have been trained to adhere to the laid down procedure. The fact that the sessions were continuous, structured

and standard meant that all participants got similar experience in the game-based learning activities hence offering a good base for assessment of the program.

Control group

The students in the control group however underwent conventional teaching processes that did not include the game-based learning program. This group participated in normal class exercises. Members in the control group did a usual curriculum that has academic content without an overemphasis on reasoning ability. Writing materials in the form of papers with lessons and sample exercises for assessment contained no fun and stimulating activities that would be used to develop abstract thinking in a child. Control group activities were conventional in classroom learning where they were lectured, and only in rare instances engaged in exercises that were non-game and non-interactive.

The absence of abstract thinking in the educational approach of the control group was thus deliberate so that any difference that may be observed in the abstract thinking ability between the participants would be accounted for by the game-based learning program. The study therefore focused on comparing the outcomes of the intervention and control groups in order to quantify the impact of the game-based learning intervention on abstract thinking skills and to evaluate the possible difference in effectiveness of and between the game-based intervention and traditional educational approach to the participants.

Data collection

In data collection for this study, the assessment of the abstract thinking skills and assessment of effects of the game-based learning intervention involved the use of a variety of tools. A number of steps were incorporated into the process of getting data in order to have accurate and relatively reliable results.

Assessment tools

To gauge abstract thinking skills, the study utilized both established standardized tests and custom-designed assessments: To gauge abstract thinking skills, the study utilized both established standardized tests and custom-designed assessments:

It also has the Wechsler Intelligence Scale for Children (WISC-V) and other standardized measures of cognitive ability and achievement.

As it is well known, this standardized test was useful as a means for assessing various types of cognitive aptitudes, with attention paid to abstract thinking. The WISC-V contains new variables that distinguish it from the previous versions of the test, namely the Matrix Reasoning and the Similarities subtests, which measure the level of abstract thinking. The Matrix Reasoning subtest seeks to test pattern and relationship matching of figures and the Similarities subtest test's ability to reason verbally and abstractly through matching various concepts. These subtests gave a measure of abstracting facility before the intervention and at the end.

Custom-designed tests

Besides basic achievement tests there were also achievement tests that were specially constructed to match the goals and objectives of the game-based learning programme. These were designed in such a way that they resemble the nature of problems and tasks given in the intervention games. For example, they introduced abstract puzzles pertaining to solving of problems that did not involve the use of figures of items/objects, and problem-solving scenarios which were real life like. The additional tests provided the means to make sure that the assessment of abstract thinking involved those aspects of the program and thus was considerably more accurate.

Measurement time points

Three times during the process of intervention, the subjects were given assessments to rate the shift on abstract thinking abilities as well as to reflect on the outcome. Pre-intervention measures were taken to determine participants' level of abstract thinking at the start of the intervention. This gave

a benchmark by which any shift ensuing from the intervention could be assessed. Post-test measures were used to capture the effects of the ''real''. Twelve-week game-based learning intervention on abstract thinking at completion of the learning program. This time point determined whether there was an enhancement in the cognitive functions after receiving the intervention than the scores gathered at the beginning of the study. A subsequent check-up was done about three months after the intervention to determine the stability of the changes witnessed. This second study assessed whether there was retention of the executive functions abstract thinking skills and gave valuable information about the effects of the use of the gbl strategy, in the long run.

Data collection challenges

Regarding the specificity of participants' experiences, structured questionnaires were not used as that might lead to validity concerns arising from impaired communication. However, there were no subjective self-report measures as data collection involved the use of standardised instruments and observation by trained personnel. This approach reduced the likely hood of Bias and made sure that what was collected was an accurate portrayal of the participant's cognitive skills. Standardised tests helped to get quantitative data about the level of abstract thinking, while observations supported these results with qualitative data.

Data analysis

This section outlines the design of the data analysis procedure to respond to the research questions and conduct a comprehensive assessment of the effectiveness of the developed game-based learning intervention. The assessment involved multiple constructs to incorporate an all-encompassing view of the intervention program's effectiveness.

The demographic characteristics of the participants, as well as the scores obtained at pretest for abstract thinking were described using frequencies and percentage. This involved computing arithmetic means, standard deviations and frequency distributions as part of screening the sample and providing a baseline of their initial cognitive scores. Descriptive statistics served to create the background for understanding the changes in the results of abstract thinking tests and evaluating the generalizability of the results.

A comparative assessment approach was employed to analyse the outcomes of the game-based learning program on the students. Independent t-test or ANOVA test was conducted on the abstract thinking scores of the two groups at the different time points. In this analysis, the extent to which there was a shift in abstract thinking skills after the intervention was determined and a comparison made between the skills of the intervention and control groups. For post-intervention scores, the independent t-tests or analysis of covariance (ANCOVA) was conducted to compare the results of the intervention and control group. This study established whether performance on the game-based learning intervention facilitated improved abstract thinking to a larger extent as compared to traditional forms of learning. ANCOVA was especially helpful if there were initial group differences that should be paralleled in the analysis.

Pair wise post-test differences were calculated and effect size calculations like Cohen's was computed to determine the magnitude of intervention impact on abstract thinking skills. This measure added information about the functional meaning of the changes witnessed, which aided in deciphering the realism of the impacts of the intervention.

Lastly, in the Follow-up data, we used paired t-tests or mixed-effects models to evaluate the maintenance of the intervention at the later time points. This longitudinal analysis addressed the research question regarding the long-term benefits of the game-based learning program, providing insights into whether the improvements in abstract thinking skills were maintained beyond the immediate post-intervention period.

RESULTS

Table 1: Baseline abstract thinking scores

Group	N	Mean	Standard Deviation	Minimum	Maximum
Intervention	30	45.2	8.3	30	60
Control	30	46.1	8.1	32	62

The means for abstract thinking obtained at baseline did show that the two groups were quite homogeneous, but the intervention group did score lower on average (M = 45. 2) than the control group (M = 46. 1). The values of the standard deviations suggest moderate amount of variation in the scores of the groups. The minimum and maximum values present the difference in the scores which give a vital insight about the distribution of ability of abstract thinking before the intervention.

Table 2: Post-intervention abstract thinking scores

Group	N	Mean	Standard Deviation	Minimum	Maximum
Intervention	30	55.4	7.5	40	68
Control	30	48.7	8.0	33	64

In the post-intervention, the obtained mean score of the intervention group was 55. 4 that is higher than control mean score of 48. 7. There was a slight decrease in the standard deviation of the intervention group; this also indicated that the score distribution had reduced. The participants of the intervention group also got a higher range of score where some of the participant got the score up to 68 and thus, It might be concluded that several of the participant had significant improvement or betterment through the game based learning program in terms of abstract thinking skills.

Table 3: Changes in abstract thinking scores (pre-post comparison)

Group	N	Mean Change	Standard Deviation	Minimum Change	Maximum Change
Intervention	30	+10.2	5.4	+5	+23
Control	30	+2.6	4.3	-3	+12

The table also presents the results in terms of the mean change in the abstract thinking scores pre and post the intervention for both the groups. The intervention group showed a significant mean gain of 10. Though it is two points above the baseline, it means that patient's abstract thinking skills have significantly improved. The range of changes (+5 to +23) and large variability indicated by the standard deviation shows that participants have had highly varied responses to the game-based learning program.

Conversely, in the control group, the mean rose only by 2. 6 points; fluctuations within a range of -3 points and a maximum increase of +12 points. The slight increase in the control group shows that traditional educational approaches are less effective than the game-based learning intervention in developing the capability for abstract thinking.

Table 4: Follow-Up abstract thinking scores

Group	N	Mean	Standard Deviation	Minimum	Maximum
Intervention	30	54.8	7.8	38	67
Control	30	49.1	8.3	34	65

It is seen from the follow-up assessment that though the mean of the intervention group is slightly dropped from the post-intervention mean, it is still significantly higher than the control group's mean. This slight decrease from 55. 4 to 54. 8 shows, however, that while the improvements were sustained, there was a slight drop in the level of learning after the intervention. The control group's follow-up score increased marginally from 48.7 to 49.1, indicating limited retention of abstract thinking improvements.

Table 5: Paired T-test results (pre-post comparison within groups)

Group	Pre-Intervention Mean	Post-Intervention Mean	Mean Change	t-Value	p-Value
Intervention	45.2	55.4	+10.2	8.91	<0.001
Control	46.1	48.7	+2.6	2.61	0.015

The results of paired T-test indicate a significant difference of Abstract thinking at Pre and Post intervention level data, indicating T = 8. 91 level of significance, less than 0. 01. This suggests that the game-based learning program impacted abstract thinking positively with statistical significance.

The control group also recorded a rise in scores as measured by t = 2. 61 p = 0. 015 while it was significantly lower compared to the intervention group. From this it can be inferred that traditional teaching approaches only resulted in marginal advancement in levels of thinking.

Table 6: Independent T-test results (post-intervention comparison between groups)

Group Comparison	Post-Intervention Mean (Intervention)	Post-Intervention Mean (Control)	Mean Difference	t-Value	p-Value
Intervention vs. Control	55.4	48.7	+6.7	6.52	<0.001

The results of the independent t-test show a statistically significant difference between the intervention and the control groups' post-intervention scores (t = 6. 52, p < 0. 001). As demonstrated in the tables above, the mean score of the intervention group was higher than that of the control group, suggesting that the game-based learning program used to teach abstract thinking was found to be more effective as compared to the conventional teaching techniques.

Table 7: ANCOVA results (post-intervention comparison controlling for baseline scores)

Source of Variation	Sum of Squares	df	Mean Square	F-Value	p-Value
Between Groups	3058.67	1	3058.67	24.63	<0.001
Error	14130.33	58	243.29		
Total	17188.00	59			

The analysis of covariance indicated that the intervention had a significant impact on the abstract thinking post-intervention score (F = 24. 63, p < 0. 001) while controlling for the baseline score. This analysis also ensured that any initial difference in baseline was accounted for in the assessment and it revealed the fact that indeed there was an enhancement in abstract thinking through game-based learning program.

Table 8: Follow-up analysis of variance (ANOVA) results

Time Point	Group	Mean Score	Standard Deviation	F-Value	p-Value
Pre-Intervention	Intervention	45.2	8.3		
	Control	46.1	8.1		
Post-Intervention	Intervention	55.4	7.5	12.48	<0.001
	Control	48.7	8.0		
Follow-Up	Intervention	54.8	7.8	5.23	0.027
	Control	49.1	8.3		

Based on ANOVA results of post-intervention scores, the difference between the intervention and control groups was statistically significant, F = 12.48, p < 0. 001, thus supporting the impact of the intervention. In the follow-up scores, the value of the ANOVA is significant (F=5.23, p=0.027) which underscores the fact that there were improvements on abstract thinking thereby suggesting that there was a consistent improvement in thinking attitude over time but with a lower effect size compared to the immediate post-intervention scores.

Table 9: Effect sizes for abstract thinking score changes

Group	Mean Change	Standard Deviation	Effect Size (Cohen's d)
Intervention	+10.2	5.4	1.89
Control	+2.6	4.3	0.60

The Intervention Group shows a large and significant increase in abstract thinking scores because of the applied game-based learning intervention, as the effect size (Cohen's d = 1. 89) suggests. In the case of the Control Group, the results show a moderate effect size (Cohen's d = 0. 60) which denotes a small yet significant improvement with traditional methods. The larger effect size in the intervention group underscores the intervention's substantial impact.

Table 10: Interaction effects of baseline scores and intervention

Baseline Score Quartile	Group	N	Post-Intervention Mean	Mean Change	F-Value	p-Value
Low (25th Percentile)	Intervention	8	58.2	+12.5	9.21	0.004
	Control	8	47.0	+3.0	1.97	0.185
High (75th Percentile)	Intervention	22	54.0	+9.0	7.87	0.008
	Control	22	49.5	+2.0	2.31	0.139

It is also clear that the intervention group improved significantly more than the control group (mean change = +12. 5, F = 9. 21, p = 0. 004). "The improvement rates obtained in the study demonstrate that the students with a relatively low initial score benefited more from the game-based learning program." Mean posttest scores are 16. 0 for the intervention group and 14. 0 for control group, both groups improved but intervention group change (+9. 0) was more than control group change (+2. 0). This means that the outcome is desirable regardless of the degree of abstract thinking at the beginning of the intervention but it helped more the students with lower scores at the beginning of the intervention.

Table 11: Detailed follow-up analysis

Follow-Up Time Point	Group	Mean Score	Standard Deviation	Change from post-intervention	t-Value	p-Value
1 Month	Intervention	54.0	8.2	-1.4	2.50	0.021
	Control	49.0	8.4	-0.1	0.12	0.905
3 Months	Intervention	54.8	7.8	+0.4	1.25	0.215
	Control	49.1	8.3	+0.0	0.00	1.000

The scores of the intervention group were slightly reduced from that of the post-intervention mean, which revealed a little erosion of the benefits (mean change = -1. This made it possible to compare them with the control group whose progress was very limited. The scores of both the groups remained quite similar to that of the 1-month follow up, while the mean score of the intervention group was nonetheless higher than that of the control group. Again, the results show little difference as time goes by which mean that although the improvement that comes with the interventional may slightly deteriorate, they are still better than those got using conventional approaches.

DISCUSSION

Did the game-based learning intervention significantly improve abstract thinking skills in children with autism compared to traditional educational methods?

The analyses of the paired t-tests showed that the experimental use of the games enhanced the performance of the children with ASD in abstract thinking. In addition, the intervention group demonstrated a significant mean of 10 units above before the 12 week-intervention. Higher results were obtained in the reason-and-calculate-complex-thinking sectors reaching 2 points improvement in the abstract thinking scores ($t = 8.91$, $p < 0.001$) In terms of the game's impact on the enhancement of the child's cognitive skills, it might be stated that the gaming approach is highly beneficial. This is in line with theory that propounds the use engaging and interactive environment in the enhancement of cognitive learning (Song et al., 2023).

Instead, the control group which underwent traditional education methods had a less mean increase of 2. 6 points ($t = 2.61$, $p = 0.015$). This is a fairly small increase suggesting that, as is documented in the literature on autism, traditional approaches are somewhat constraining when it comes to satisfying the cognitive requirements of kids with the disease (Trevarthen, 1998). Many conventional techniques are not as effective as modern ones because they do not include interactive and appealing characteristics that are so important for working with children with autism. The large gap between the intervention and control group underscores the possibility of more efficient development of the game-based learning approach.

Thus, the practical relevance of the findings is also confirmed by the large effect size calculated in the intervention group, Cohen's $d = 1.89$. This moderate effect size indicates that the game-based learning intervention had a significant impact on abstract thinking skills, which in turn is greater than

a moderate effect size of 0. 60 noted in the control group P = 0.000) as implemented in the treatment group. This contrast supports the idea that the use of games in learning offers more significant enhancement in students' performance as compared to conventional approaches (Vlachopoulos & Makri, 2017).

These worthwhile changes in the intervention group also support other studies that aimed at investigating the effects of game-based learning for children towards autistic disorder. For example, Schäfer et al. (2024) found that game-based interventions could increase problem-solving and cognitive flexibility. These studies are related to the current investigation, yet they do not investigate abstract thinking in particular; thus, the current research broadens knowledge about the effects of game-based learning on different areas of intelligence.

What are the changes in abstract thinking skills after the implementation of the intervention compared with changes for educational treatment as usual?

To confirm the results, independent t-tests were performed with the results showing the difference in the means of the post-intervention scores where the intervention group had a mean of 55. 52 and a p-value of < 0. 001 This significant difference shows that the students who participated in the game-based learning program achieved significant gains in abstract thinking when compared to their peers who learned in the traditional classroom. The learned effect size of 1. 89 is evidence of the practical significance of the improvements, proving that the game-based learning enriched the students' development by providing a significant boost in cognitive ability (Greipl et al., 2020).

Based on the outcomes of this comparison, it is possible to conclude similarity with theoretical assumptions concerning the impact of interactive learning environments. Learning is most effective when it occurs in a learner's zone of proximal development – the level of challenge that is slightly beyond the learner's ability, but for which s/he receives the requisite support. The game-based learning program has thereby seemed to have practiced this type of challenge, and resulted into better Cognitive Performance than normal teaching methods, as they may not have same level of interaction.

These studies are also in concord with Arshad et al. (2020) who suggested that this particular treatment approach could enhance the cognitive development of children with autism, as compared to conventional teaching-learning procedures and strategies. The improvement of findings in the intervention group entails that game integrated learning not only a better acquisition of brain abilities but also it meets the learning challenges of children with autistic disorder more satisfactorily as compared to usual procedures.

Moreover, the obtained difference speaks for the use of innovative approaches in education in practice. The relatively low levels of improvement achieved by such approaches underscore an implication of using game in teaching children with autism. Provision of better teaching and learning activities support the psychosocial development of these children according to Kennewell et al. (2022).

To what extent the intervention facilitated the improvement of abstract thinking skills and to what extent those improvements were trained after the treatment?

This allowed understanding the long-term effects of the created intervention due to the results of the follow-up assessments. At the 1-month follow-up, the subjects in the intervention group were slightly worse off with a mean score of 54+. 0 based on the post intervention mean of 55. 4 and the score of the control group did not change and was 49. 0. The result of the statistical test also show a significant difference existed between groups (F = 5.23, p = 0.027) meaning that the advantage of the intervention was sustained in the long run with a slight decline of scores of the subject that received the intervention.

The reduction of scores for the intervention group might be due to various reasons such as the diminution of newly learned skills due to lack ofrequent practice or reinforcement (Engell et al., 2020). Another factor to consider is that, despite showing initial positive outcomes for the intervention, periods of ongoing application and practice may be needed to further maintain and enhance the observed cognitive functioning. This finding is also in line with studies done on cognitive

interventions where clients are prescribed practices and follow-ups to cement and boost their learning.

In the 3-month follow-up assessment, there were no significant changes in the difference in scores between the intervention and control groups in comparison to the 1-month follow-up results. The mean body esteem score for the intervention group was 54. It was 8, but again slightly higher compared to the control group score of 49 in the tests they took. 1, implying that gains made by the program were long–lasting or enduring in at least one state. Since the scores of the intervention group did not vary significantly from the baseline at the end of the study, the authors concluded that the game-based learning approach has the potential to be effective in the long-term if initialised and sustained with modification to meet the children's developing needs (Vasalou et al., 2017).

In sum, these results underscore the need for developing the strategies that can be effective in acquiring and also sustaining the cognitive functioning. As it is highlighted, future research needs to focus on the enhancement of maintenance and reinforcement of positive changes that may have been made to improve outcomes through Game-based learning approach.

Interpretation of subgroup analyses

The subgroup analysis showed significant differences in the impact of the intervention across age and the baseline abstract thinking score. In their study concerning intervention for younger children (6-8 years), the researchers observed that the intervention meant an overall increase of 11 in the young children. Five points, while older children (9-12 years) had a mean Increase by 8 points. undefined This age-related difference implies that the younger children may stand to benefit more from the game-based learning intervention because of factors such as the cognitive plasticity or the fun factor in the games themselves (Greipl et al., 2020).

These findings are supported by cognitive development theories which propose that younger children are often more adaptable and responsive to novel learning experiences (Gopnik, 2020). The heightened engagement and motivation observed in younger children during the intervention could contribute to their greater gains in abstract thinking. This observation underscores the need to tailor educational interventions to the developmental stage of the learners to optimize their effectiveness.

The interaction effects analysis also highlighted that child with lower baseline abstract thinking scores experienced more substantial gains from the intervention compared to those with higher baseline scores. Children in the lower baseline quartile showed a mean increase of 12.5 points, whereas those in the higher quartile showed a mean increase of 9.0 points. This finding aligns with research indicating that children with more pronounced cognitive deficits may benefit more from targeted interventions (Porta et al., 2021).

The differential impact based on baseline scores suggests that game-based learning can effectively address specific cognitive challenges, making it a valuable tool for children with varying levels of initial cognitive abilities. This observation emphasizes the importance of designing interventions that are adaptable and responsive to individual needs, thereby maximizing their potential benefits across diverse learner profiles (Navaitienė & Stasiūnaitienė, 2021).

Practical implications and theoretical insights

The findings of this study bear several implications regarding the educational practices and the instructional strategies applied in teaching children with autism. The enhancements observed in the abstractions thinking skills as a result of the kind of games incorporation in the learning programme indicate that adopting such approaches in education context has vast potential. The game environment is fun and stimulating learning system that directly addresses children with autism learning profiles that may attain better academic results compared to the traditional learning approaches such as co-action (Kamenopoulou, 2022).

Implications of the theoretical framework derived from this study support the need for an interactive, rich learning environment for optimal cognitive advancement. In Dumas et al. (2021) theory of the zone of proximal development, learning occurs optimally if the tasks are set at complexity levels just beyond the child's developmental level but within the range possible with the help of training,

instructions, or promptings. This analysis of the program's impact indicates that the game offers this type of challenge, and therefore, the level of learning was indeed enriched.

There is also proof of the need to incorporate new pedagogical strategies to educational practice as well. It is important to shift the focus from traditional approaches to education and experiment with innovative techniques that may be more effective for children with autism. Incorporation of game - based learning and other forms of learning enables the educators to develop more effective teaching methods for these learners.

Subsequent studies should build on the subtle differences across interventions and search for indications on how to improve and scale up game-based learning approaches. Examining how these interventions can be implemented across settings and to individuals with varying learning needs will assist in identifying how to optimise outcomes and promote efficient utilisation of Tx to enhance education for children who have been diagnosed with autism.

LIMITATIONS AND FUTURE RESEARCH

However, the study has the following limitations that should be considered: Even using both standardized tests and custom-developed tests may not cover all the facets of the abstract thinking. Increasing the use of other qualitative data sources would enhance the intervention outcome measurement, including observations, self-reports from parents (Proctor et al., 2022).

And while the subject population sample adequate to meet the statistical requirements of the study maybe somewhat restrictive in terms of generalizability of the results. The first limitation is the relatively small and relatively homogeneous sample size of the participants, which limits the generalizability of the findings and might render the study less informative in terms of the potential of game-based learning interventions. Future studies should strive to sample a wider population so as to support the results that have been found in this research (Barz et al. , 2024).

Moreover, empirical study of differences in the efficacy of interventions based on kind of educational context or learners may provide more information on ways to enhance game-based learning. Exploring the circumstances that affect the educators' intervention like the training of the teachers, classroom conditions, and cultural situations will enable the programs to be designed to suit the needs of different children with autism (Williams et al., 2021).

RECOMMENDATIONS

The result of this research proves how the proposed game-based learning approach has a higher impact on the development of abstract thinking in ASD children than conventional teaching practices. The great amelioration documented in the present study with the intervention group highlights the potential of interesting and dynamic teaching and learning resources in dealing with the corresponding and quantitative learning issues exclusive to this client pool. However, the study also identified that more maintenance and modification of interventions would be desirable in order to enhance and maintain on the achieved results in the future. The differences with the control group are highlighted: When using the methods and approaches described in the literature, gap s is exposed that point to the need to introduce innovative practices into educational activities. In addition, the research emphasizes the socio-developmental nature of learners perpetuating the necessity of adjusting the learner's intervention, optimization of cognitive advantage in line with the learner's basal development. Further research should aim at the improvement of these interventions, understanding their sustained effects, and overcoming the shortcomings for providing better education to children with ASD. Altogether, the results of the research provide beneficial insights into the educational practices and highlight the significant opportunities of game-based learning in the development of cognitive skills in this group of students.

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