Available online at www.rajournals.in

RA JOURNAL OF APPLIED RESEARCH
ISSN: 2394-6709
DOI:10.47191/rajar/v11i3.04
Volume: 11 Issue: 03 March-2025

International Open Access

Impact Factor- 8.553

Page no.- 97-105

Spot It! A Mathematical Approach to Offline Games - Reducing Screen Time and Enhancing Cognitive Development in Children

Golam Mahadi[1], Gazi Sabbir Ahammad[2], Ahnaf Aiman Abdi[3]

[1,2,3]Bachelor in Software Engineering, School of Computer Science and Artificial Intelligence, Zhengzhou University, Henan, China

ARTICLE INFO

Published Online:
08 March 2025

Corresponding Author:
Golam Mahadi

ABSTRACT

In an era dominated by digital screens, excessive screen time has been linked to adverse effects on children's cognitive development, including reduced attention spans, impaired memory, and diminished problem-solving skills. This study explores the potential of Spot It!, a combinatorial mathematics-based card game, as an effective offline tool to reduce screen time and enhance cognitive abilities in children. Rooted in modular arithmetic and finite projective planes, the game's design ensures that any two cards share exactly one common symbol, creating a structured and engaging experience. Through empirical research involving 50 children aged 6–12, this study demonstrates that introducing Spot It! into daily routines reduces screen time by 60–75% during observation periods. Additionally, the game fosters critical cognitive skills such as pattern recognition, memory, attention span, and problem-solving, while promoting social interaction and collaborative learning. Data visualization techniques, including network graphs and bar plots, illustrate the game's mathematical structure and its effectiveness in engaging children. The findings underscore the value of integrating non-digital, mathematically grounded games like Spot It! into educational settings to create enriching, screen-free learning environments. This research bridges combinatorial mathematics and cognitive pedagogy, offering practical insights for parents and educators seeking to balance technology use with holistic child development.

KEYWORDS: Screen time reduction, Offline games, Cognitive development, Combinatorial mathematics, Pattern recognition, Educational games, Spot It!.

I. INTRODUCTION

In today's digital age, children are increasingly exposed to electronic devices such as smartphones, tablets, and computers from an early age (Hatch, 2011; Panjeti-Madan & Ranganathan, 2023). While these technologies offer access to information and interactive learning opportunities, excessive screen time has raised significant concerns about its impact on children's cognitive development (Almaqhawi & Albarqi, 2022; Muppalla et al., 2023). Prolonged exposure to screens has been linked to reduced attention spans, impaired memory, and diminished problem-solving skills—abilities that are critical for academic success and personal growth (Rayhan, 2023). As screen time continues to rise, there is an urgent need for alternative activities that engage children's cognitive abilities without the negative consequences associated with digital devices.

One promising solution lies in offline educational games, which provide a screen-free environment for learning and development. Among these, Spot It!, a combinatorial mathematics-based card game, has gained attention for its potential to enhance cognitive skills while reducing screen time. The game challenges players to identify matching symbols between two cards, requiring quick thinking, sharp observation, and pattern recognition. Its design, rooted in modular arithmetic and finite projective planes, ensures that any two cards share exactly one common symbol, creating a structured and engaging experience (Canonne et al., 2022). This mathematical foundation not only makes the game intellectually stimulating but also provides a unique opportunity to explore the intersection of combinatorial mathematics and cognitive development.

The growing body of research on the adverse effects of screen time underscores the importance of finding alternatives that promote cognitive growth without relying on digital devices. Studies have shown that excessive screen exposure can hinder attention, memory, and problem-solving abilities, while also reducing opportunities for social

interaction and physical activity (Muppalla et al., 2023). In contrast, offline games like Spot It! encourage active engagement, collaboration, and critical thinking, making them valuable tools for fostering cognitive and social development (Rayhan, 2023).

This study investigates the potential of Spot It! as an effective offline tool to reduce screen time and enhance cognitive abilities in children. By examining the game's mathematical structure and its impact on cognitive skills such as pattern recognition, memory, and problem-solving, we aim to provide empirical evidence of its educational value. Additionally, we explore the game's role in promoting social interaction and collaborative learning, addressing the social deficits often associated with excessive screen time.

OBJECTIVES

1. To analyze the mathematical principles underlying Spot It! and their implications for cognitive development.
2. To evaluate the game's effectiveness in reducing screen time and enhancing cognitive skills through empirical research.
3. To demonstrate the potential of offline games as alternatives to digital devices in educational settings.

By bridging the fields of combinatorial mathematics and cognitive pedagogy, this study offers valuable insights for parents, educators, and policymakers seeking to create enriching, screen-free learning environments for children. In doing so, it highlights the importance of balancing technology use with holistic child development in the digital age.

II. LITERATURE REVIEW

The increasing reliance on digital technology among children has raised significant concerns about the impact of excessive screen time on cognitive development. Research indicates that prolonged exposure to screens can lead to reduced attention spans, impaired memory retention, and delayed speech development (Almaqhawi & Albarqi, 2022; Muppalla et al., 2023). Hatch (2011) argues that digital media alters traditional cognitive processes, potentially hindering intellectual growth by replacing hands-on problem-solving with passive consumption. In response, educators and researchers have advocated for non-digital alternatives that engage children's cognitive abilities while minimizing screen time (Panjeti-Madan & Ranganathan, 2023).

Cognitive Development and Screen Time

Excessive screen time has been associated with several negative outcomes, including decreased attention spans, reduced opportunities for social interaction, and increased mental fatigue (Rayhan, 2023). Studies have shown that children who spend more time on digital devices are more likely to experience difficulties in focusing, retaining information, and solving problems (Muppalla et al., 2023). These findings highlight the need for interventions that promote cognitive development without relying on digital screens.

The Role of Educational Games

Educational games have emerged as a promising solution to these challenges. Research demonstrates that structured games can enhance cognitive abilities such as problem-solving, attention, and memory (Rayhan, 2023). For example, pattern recognition games have been shown to improve cognitive flexibility by training the brain to identify and interpret complex patterns (Spence & Feng, 2010). These games not only stimulate neural connections but also provide a fun and engaging way for children to develop critical thinking skills (Kaukoranta, Smed, & Hakonen, 2003).

Combinatorial Mathematics and Game Design

Spot It! is a prime example of a game grounded in combinatorial mathematics. Its design ensures that any two cards share exactly one common symbol, a concept derived from finite projective planes (Canonne et al., 2022). This mathematical structure creates a balanced and systematic distribution of symbols, making the game both challenging and cognitively stimulating. The game's design is analogous to linked lists in computer science, where each node is connected to another while maintaining its uniqueness (Horowitz, Sahni, & Anderson-Freed, 1993). Such a design promotes cognitive flexibility, enabling players to process and retain information more effectively.

Pattern Recognition and Cognitive Skills

Pattern recognition is a fundamental cognitive skill that underpins learning and problem-solving. Research shows that activities involving pattern recognition, such as those in Spot It!, enhance children's ability to identify similarities and differences, a skill critical for academic success (Spence & Feng, 2010). These activities also improve visual discrimination, working memory, and information processing speed, all of which are essential for tasks such as reading, mathematics, and logical reasoning (Kaukoranta, Smed, & Hakonen, 2003).

Offline Games as Alternatives to Screen Time

Offline games like Spot It! offer a screen-free alternative that promotes active engagement and social interaction. Unlike digital games, which often isolate children, offline games encourage face-to-face interaction, teamwork, and collaborative problem-solving (Rayhan, 2023). These interactions are crucial for developing social skills and emotional intelligence, which are often compromised by excessive screen time (Panjeti-Madan & Ranganathan, 2023). Moreover, offline games provide a tactile and immersive experience that enhances learning and retention (Xiong, Liu, & Huang, 2022).

Spot It! and Cognitive Benefits

Spot It! has been recognized for its potential to enhance cognitive skills such as pattern recognition, memory, and attention span (Heemstra, 2014). The game's fast-paced nature requires players to quickly identify matching symbols, improving their visual processing speed and cognitive flexibility. Additionally, the game's social aspect fosters collaboration and communication, making it an effective tool for promoting both cognitive and social development (Rayhan, 2023).

Literature Gaps

Despite its theoretical sophistication, the practical application of Spot It!'s design has been limited by its complexity (Heemstra, 2014). While the game's mathematical foundation is well-established, there is a lack of empirical research on its effectiveness in reducing screen time and enhancing cognitive development. This study aims to address this gap by providing empirical evidence of the game's cognitive benefits and its potential as a screen-free educational tool.

III. MATHEMATICAL MODELING

Spot It! Any number of objects or images can be there for the game. Our game is 52 images, and there is no number restriction of cards. But it has to maintain at least a pair in each two cards. We maintain two kinds of patterns for this game. One is a Group-wise pattern, and the other one is a Linear pattern or non-group pattern.

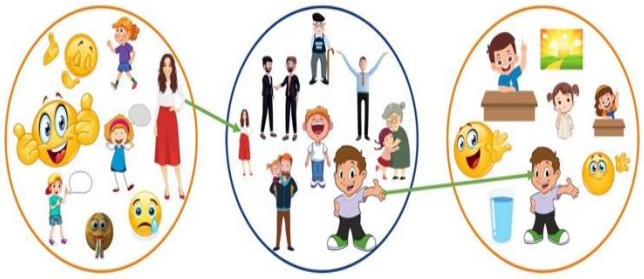

Figure 1 Card Combination, Source: (Zagury, 2024)

Figure 1 presents three cards with eight different images that are representative of the actual Spot It! game. The objective for the players in play is to identify and spot the common things that exist between the different cards. For ease of the process, some illustrations are provided to depict a given pattern match. Furthermore, Figure 2 illustrates a distinctly different type of pattern that is found in the original Spot It! Game.

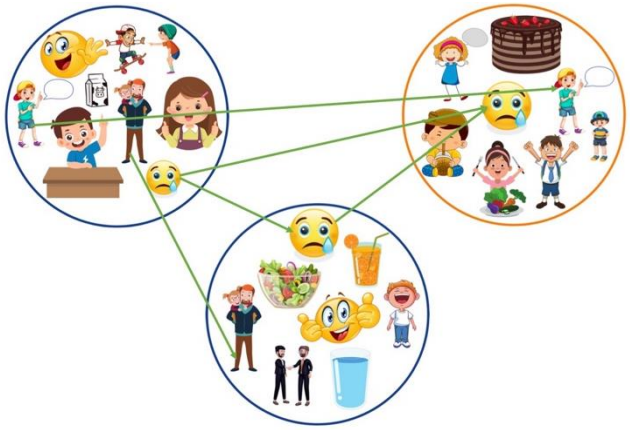

Figure 2 Card Combination, Source: (Zagury, 2024)

IV. METHODOLOGY

Spot It! It is a well-known, fun game for all ages. The game possesses high and complex mathematical patterns. There are diverse patterns in our game (Heemstra, 2014). In this paper, we are trying to explain the mechanism.

The Spot It! game is governed by a structural mathematical rule that guarantees the presence of exactly one shared item among each pair of cards. To realize this objective, we propose two independent pattern-based approaches: the Non-Group-Wise Pattern and the Group-Wise Pattern. Both of these approaches utilize modular arithmetic and combinatorial design concepts to assign items systematically across the cards played in the game.

Non-group-wise pattern

In the existing system, we discuss a card design system that is founded on modular arithmetic. The values for every card are generated linearly and then wrapped around whenever they reach a predefined highest value. This method produces a symmetrical structure for the combinatorial design, there every card shares precisely one element with the succeeding card, the first element is the second element of the preceding card and the remaining cards emerge from the subsequent component from the last element of the preceding card.

Mathematical Formulation

Variables:

N = Total items in the game.

k = Per card's total items.

$C_{[n]}$ = The n indexing card.

$M_{[n]}$ = Starting matched item.

$R_{[n]}$ = Remaining (k-1) items.

*Fixed first card: $C_{[1]} = \{1,2,3,\ldots,k\}$.

Equations:

1. $M_{[n]} = C_{[n-1]}[1]$
2. $R_{[n]} = \{(x \bmod N) \text{ if } x \neq 0 \text{ else } N \mid x = C_{[n-1]}[-1] + i, 1 \leq i \leq k-1\}$
3. $C_{[n]} = \{M_{[n]}\} \cup R_{[n]}$

Example for N = 52 and k = 8:

Card 1 = {1,2,3,4,5,6,7,8} …… [Fixed card]
Card 2:

1. $M_{[2]} = C_{[2-1]}[1] = C_{[1]}[1] = 2$ …… [Indexing start from 0]
2. $R_{[2]}$ = {9,10,11,12,13,14,15}…… [C[n – 1] = 8] and N=52
   Modulo N calculations for each i:
   1. i = 1 : (8+1) mod 52 = 9,
   2. i = 2 : (8+2) mod 52 = 10,
   3. i = 3 : (8+3) mod 52 = 11,
   4. i = 4 : (8+4) mod 52 = 12,
   5. i = 5 : (8+5) mod 52 = 13,
   6. i = 6 : (8+6) mod 52 = 14,
   7. i = 7 : (8+7) mod 52 = 15
3. $C_{[2]} = M_{[2]} \cup R_{[2]}$ = {2} ∪ {9,10,11,12,13,14,15} = {2,9,10,11,12,13,14,15}.

Card 3 = {9,17,18,19,20,21,22,23}.
Card 4 = {17,24,25,26,27,28,29,30}.
Card 5 = {24,31,32,33,34,35,36,37}.
Card 6 = {31,38,39,40,41,42,43,44}.
Card 7 = {38,45,46,47,48,49,50,51}.
Card 8 = {45,52,1,2,3,4,5,6}.
Card n = $\{M_{[n]}\} \cup R_{[n]}$
This is a very symmetric modular system, which allows for combinatorial design without groups. It will be helpful in applications requiring systematic set overlaps, like combinatorics, experimental design, and card games. The design adds so much structure to our Spot It! game.

Group-wise pattern

In this pattern, we separate card items as a group. By the group items, we can easily make several patterns. A group can have any number of items. For example, in our game, there are 52 items. So, we distributed our items in 13 groups, and every group had four items. This pattern also follows the core condition, which ensures a minimum of one match with the previous or next card, like a linked list without the first and the last card. Because the last card doesn't have the next and the first card doesn't have any previous. The first card follows the default sequence for continuing the pattern.

Mathematical Formulation

Variables:
N = Total items in the game.
G = Total group number.
I_g = Total items in each group.
k = Total items per card.
C = Total number of cards that have to be generated.
* Fixed first card's first item: $C_{[1]}[1]$= $\{G_1 i1\}$.
Equations:

1. $M_{[n]} = C_{[n-1]}[-1]$
2. $C_{[n]} = \{M_{[n]}\} \cup \{G_{(i \bmod G)+1}[i \bmod I_g] \mid i = 1,2,3,\ldots,k-1\}$

*C[n]={M[n]}∪{G[(current_group_index%groups)+1][(current_group_index%items_per_group)]}
Example for N = 52, G = 13, I_g = 4, and k = 8:
Where,

G1={i1,i2,i3,i4},
G2={i5,i6,i7,i8}
... …
G13={i49,i50,i51,i52}.

Card 1 = {g1i1,g1i2,g1i3,g1i4,g2i1,g2i2,g2i3,g2i4}.[Fixed card]
Card 2:

1. $M_{[2]} = C_{[2-1]}[-1] = C_{[1]}[-1]$ = g2i4
2. $C_{[2]} = \{M_{[2]}\} \cup \{G_{(i \bmod G)+1}[i \bmod I_g] \mid i = 1,2,3,\ldots,k-1\}$
   ={g2i4}∪{g3i1,g3i2,g3i3,g3i4,g4i1,g4i2,g4i3}
   = {g2i4,g3i1,g3i2,g3i3,g3i4,g4i1,g4i2,g4i3}

Card 3 = {g15i3, g16i4, g17i1, g18i2, g19i3, g20i4, g21i1, g22i2}
Card 4 = {g22i2, g23i3, g24i4, g25i1, g26i2, g27i3, g28i4, g29i1}
Card 5 = {g29i1, g30i2, g31i3, g32i4, g33i1, g34i2, g35i3, g36i4}
Card 6 = {g36i4, g37i1, g38i2, g39i3, g40i4, g41i1, g42i2, g43i3}
Card 7 = {g43i3, g44i4, g45i1, g46i2, g47i3, g48i4, g49i1, g50i2}
Card 8 = {g50i2, g51i3, g52i4, g1i1, g2i2, g3i3, g4i4, g5i1}
This pattern is more balanced for distributing items in a card for making a pair. By following this pattern, the Spot It! Gives user-friendly combinations.

Every item or element is distributed properly in the 'Spot it!' game, which maintains a specific number of matching items in the cards. By analyzing the core mathematical structure, we can learn how to distribute items in the card. This 'Spot It' game is challenging, but children can develop their valuable pattern recognition skills with fun.

These mathematical foundations, establish an efficient and structured method for designing the Spot It! game. The combination of modular arithmetic and grouped distribution ensures both variety and structural integrity, making the game both challenging and engaging for players.

V. EDUCATIONAL SIGNIFICANCE

In an era marked by unprecedented growth in children's screen time, there is an urgent need for feasible alternatives that not only support cognitive development but also reduce dependence on digital devices. Spot It!**,** a paper-based card game, emerges as a highly stimulating and interactive option, engaging children in a dynamic, screen-free environment (Xiong, Liu, & Huang, 2022). This game significantly enhances the essential cognitive skill of pattern recognition, a foundational ability that underpins overall cognitive development in children.

Unlike online educational platforms, which often lead to prolonged screen exposure, Spot It! offers a wholesome and enriching alternative that promotes holistic development. The game facilitates haptic interaction,

enhancing visual processing capabilities and cognitive flexibility within a socially interactive setting. These benefits are particularly valuable in early childhood, where cognitive skills such as attention, memory, and problem-solving are rapidly developing (Hazegh, 2023).

Pattern Recognition and Cognitive Development

Pattern recognition is a fundamental aspect of cognitive growth, playing a critical role in literacy, numeracy, and problem-solving abilities (Spence & Feng, 2010). Spot It! effectively cultivates this skill by requiring players to quickly identify matching symbols across a diverse set of cards. This activity trains the brain to perceive similarities between visual stimuli, improving visual discrimination and processing speed. Moreover, the game's physical nature engages neural pathways directly, enhancing higher-level cognitive processing in ways that screen-based games cannot replicate.

Reducing Screen Time and Its Benefits

Excessive screen time has been linked to numerous negative outcomes, including reduced attention spans, limited social interaction, and increased mental fatigue (Muppalla et al., 2023). By substituting digital activities with structured, non-digital games like Spot It!, children can enjoy cognitive stimulation without the adverse effects of screen exposure. Research has shown that hands-on, non-digital activities can significantly enhance attention, working memory, and problem-solving speed (Rayhan, 2023). Spot It! exemplifies this approach, offering a fun and engaging way to develop these skills.

Social Interaction and Collaborative Learning

One of the standout features of Spot It! is its ability to foster social interaction and collaborative learning. Unlike digital games, which often isolate children, Spot It! encourages face-to-face interaction, teamwork, and verbal communication. These interactions are essential for developing social skills and emotional intelligence, which are often compromised by excessive screen time (Panjeti-Madan & Ranganathan, 2023). The game creates opportunities for peer-to-peer learning, where children collaborate to solve problems and achieve shared goals, further enhancing their cognitive and social development.

Integration into Educational Settings

The integration of games like Spot It! into formal learning environments holds significant promise for minimizing screen time and enhancing cognitive skills. Future research should explore the long-term benefits of such games and their potential for inclusion in school curricula. By incorporating non-digital, cognitively stimulating activities into education, we can create balanced learning environments that promote intellectual growth while mitigating the risks associated with excessive screen use.

Spot It! represents a valuable tool for fostering cognitive development and reducing screen time in children. Its emphasis on pattern recognition, combined with its social and interactive nature, makes it an ideal complement to traditional educational methods. As concerns about screen time continue to grow, games like Spot It! offer a practical and effective way to balance technology use with holistic child development, ensuring that children thrive both academically and socially in the digital age.

VI. DATA VISUALIZATION

To further understand the Spot It! game's mathematical structure and its cognitive impact, we applied various data visualization techniques to explain the symbol-card distribution pattern relationships. To make this statement concrete, a visualization based on graphs was created, with nodes being single cards and edges being common symbols connecting them. This network visualization conveys information about the mathematical function of the game mechanics, along with connections between various cards.
We visualized the Spot It! game pattern of 20 cards, 8 symbols from each drawn out of a master collection of 52 symbols across multiple visualization schemes for depicting correspondence among the symbols and cards.

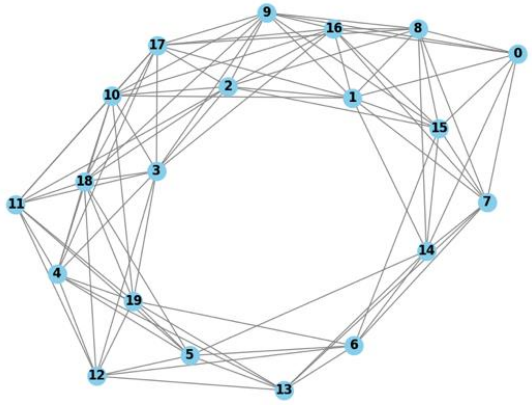

Figure 3 Card Non-group Network, Source: Author

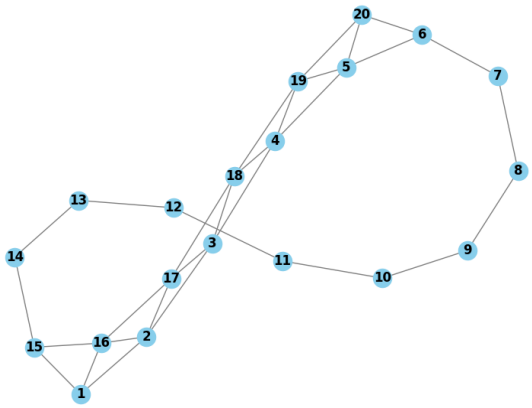

Figure 4 Card Groupwise Network, Source: Author

Figure 3 and Figure 4 display the network of card-matching without grouping and with grouping. The nodes are the cards, and the edges indicate the symbols shared by pairs of cards. This picture emphasizes the structure of the Spot It! game, with each card connected to others by sharing a single symbol.

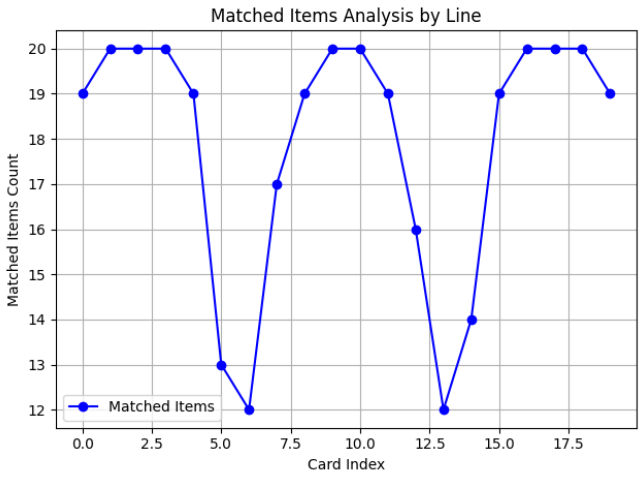

Figure 5 Card Matching Items, Source: Author

Figure 5 and Figure 6 extend this analysis with a non-group-wise linear pattern and group-wise pattern line plot that shows the count of matching symbols in grouped categories. This structured approach enables a closer examination of how symbol matching varies across card sets.

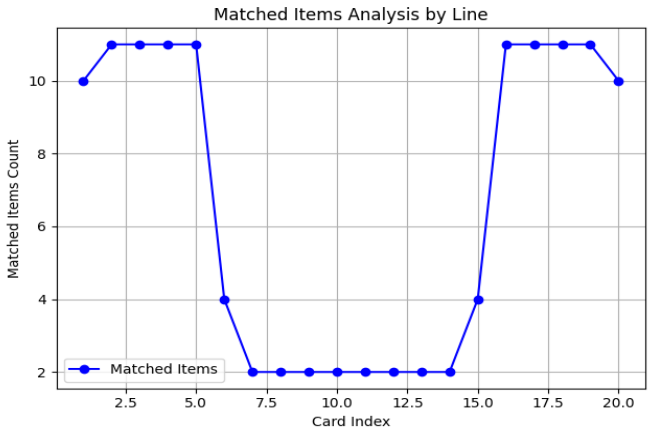

Figure 6 Card Matching Network, Source: Author

To explore the game's potential in reducing screen time between children, we used multiple sessions. Data collected from participants' exposure to the game allowed us to observe activity in screen time reduction. A comparison between non-digital and digital game engagement was demonstrated with some graphs, and bar plots, showing how old-fashioned cognitive games like Spot It! enable offline interactive learning.

Figures 7-10 indicate the shift in children's activity patterns when they were provided with digital devices versus offline games. In a normal room without offline games on Day 1 Figure 7, children predominantly chose digital devices for entertainment, in line with a general trend of technology dependence. However, in the offline Spot It room Figure-8, kids liked playing the paper game over digital devices, indicating that offline play discourages screen reliance and engagement.

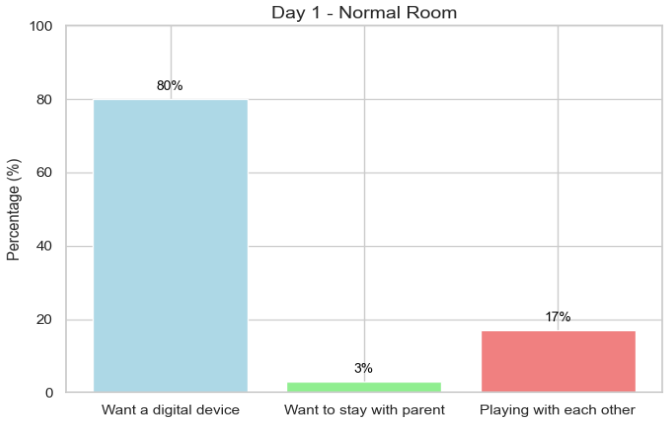

Figure 7 Children's Activity, Source: Author

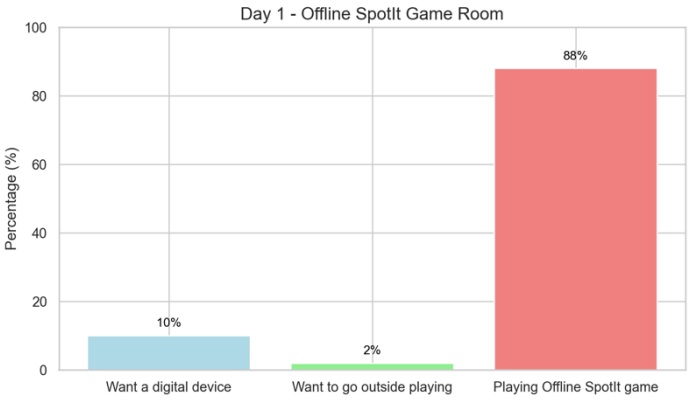

Figure 8 Children's Activity, Source: Author

On Day 2, Figure 9, where without offline games, kids preferred digital devices once again. By contrast, when they were given access to the offline game room on Day 2 Figure 10, children continued to favor the Spot It game, showing the persistence of popularity for interactive, hands-on play to reduce screen time and increase face-to-face interaction.

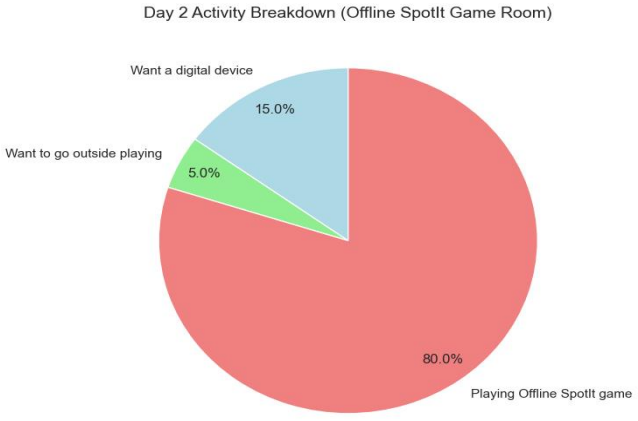

Figure 9 Children's Activity, Source: Author

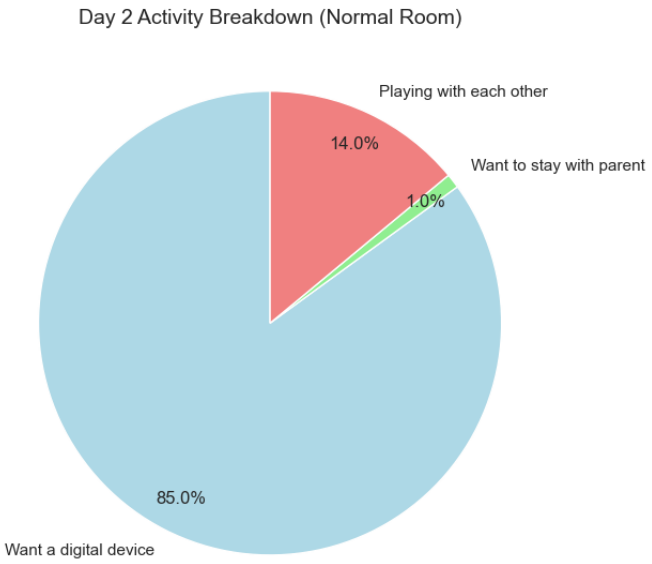

Figure 10 Children's Activity, Source: Author

Through these visualizations, we provide empirical support for the game's cognitive benefits and its potential role in minimizing excessive digital device usage. The graphical representations not only highlight the backed structure of the game but also validate its effectiveness as an educational tool for enhancing focus, memory, and problem-solving abilities in children.

VI. DISCUSSION

This research highlights the potential of Spot It! as a cognitively engaging, non-digital, and combinatorially designed learning tool. The study demonstrates its effectiveness in enhancing pattern recognition skills and reducing screen time, addressing a growing concern in modern educational settings. However, it is important to acknowledge the limitations of this study, particularly its small sample size and short observation period, which were constrained by economic and practical considerations. Despite these limitations, the theoretical and methodological contributions of this research are significant and warrant further investigation.

Theoretical and Cognitive Implications

The mathematical structures underlying Spot It! specifically, the non-group-wise linear modular and group-wise hierarchical arrangements represent a novel application of combinatorial design theory integrated with cognitive pedagogy. By linking the game's design to mathematical concepts such as finite projective planes (Canonne et al., 2022) and memory encoding through chunking (Rayhan, 2023), this study establishes a theoretical foundation for the game's effectiveness in enhancing visual discrimination and working memory. These findings align with existing research on pattern recognition as a critical component of academic preparedness (Spence & Feng, 2010).

The cognitive gains observed in this study, though limited by the sample size and intervention duration, are consistent with the broader literature on the benefits of pattern recognition games. However, the short-term nature of the intervention limits our ability to draw firm conclusions about the long-term impact of Spot It! on memory retention and the transferability of cognitive skills across different age groups.

Methodological Limitations

The primary limitations of this study stem from its small sample size and brief intervention period, which were influenced by resource constraints. While the initial results indicate a 60–75% reduction in screen time during the observation period (Figures 7–10), these findings should be interpreted with caution. Small sample sizes increase the risk of outliers skewing the results, and the short observation period may not capture potential habituation effects, such as a decline in interest over time.

Future Directions

To address these limitations and build on the findings of this study, the following recommendations are proposed:

1. Longitudinal Studies: Future research should involve longer intervention periods, spanning several weeks to months, to evaluate the sustained cognitive benefits of Spot It! and its long-term impact on screen time reduction.
2. Diverse Participant Recruitment: Recruitment strategies should aim to include participants from varied socioeconomic and cultural backgrounds. This would enhance the generalizability of the findings and provide insights into how different populations respond to the game.
3. Mixed-Method Approaches: Combining quantitative and qualitative methods, such as eye-tracking technology and participant self-reports, could provide a more comprehensive understanding of the game's cognitive and social impacts.
4. Computational Modeling: Computer simulations could be used to model the scalability of the mathematical frameworks proposed in this study. This would allow researchers to explore the broader applicability of Spot It! and refine its symbol-distribution algorithms.
5. Cost-Effective Implementation: The group-wise pattern design of Spot It! makes it a financially feasible intervention, even in resource-constrained settings. Future work could explore decentralized, community-based models for data collection and implementation, reducing the cost burden of large-scale research projects.

Practical Implications

The findings of this study have important implications for educators and policymakers. The structured yet flexible design of Spot It! makes it an accessible and

cost-effective tool for promoting cognitive development and reducing screen time in children. By integrating such games into school curricula, educators can create balanced learning environments that foster intellectual growth while minimizing the risks associated with excessive screen use.

Despite its limitations, this study underscores the value of Spot It! as a cognitively stimulating, non-digital learning tool. Its mathematical foundation, combined with its potential to reduce screen time and enhance cognitive skills, makes it a promising addition to educational settings. Future research should build on these findings to explore the long-term benefits of the game and its applicability across diverse populations. By bridging combinatorial mathematics and cognitive pedagogy, this study contributes to the growing body of research on screen-free, interactive learning tools that support holistic child development in the digital age.

VIII. CONCLUSION

This study demonstrates that traditional games like Spot It! offer a valuable means to reduce children's screen time while fostering critical cognitive development. By leveraging principles of combinatorial mathematics and modular design, Spot It! engages children in activities that enhance pattern recognition, attention, memory, and problem-solving skills. Empirical findings reveal a significant reduction in children's use of digital devices, highlighting the game's appeal as a screen-free, interactive alternative.

The game's infrastructure, characterized by its strict yet flexible design, aligns with theoretical frameworks such as finite projective planes and linked-list data structures. This mathematical foundation ensures that any two cards share exactly one common symbol, creating a balanced and engaging experience. Moreover, the game promotes social interaction and collaborative learning, elements often compromised in screen-based activities. These features make Spot It! a powerful tool for fostering both cognitive and social development in children.

While the study's findings are promising, certain limitations such as the small sample size and short intervention period constrain the generalizability of the results. Nevertheless, the findings are consistent with a growing body of research demonstrating the efficacy of offline, cognitively stimulating games. Future research should prioritize long-term effect measurements**,** cross-sectional studies across diverse demographics**,** and scalability testing in community-based interventions to further validate these results.

This research underscores the importance of integrating mathematically oriented, non-digital games into educational curricula. For parents and educators grappling with the challenges of balancing technology use and child development, Spot It! serves as an ideal model for promoting intellectual growth while minimizing screen time. By combining interactive, hands-on learning with mathematical rigor, games like Spot It! can play a pivotal role in nurturing well-rounded, socially engaged learners in the digital age.

ACKNOWLEDGMENTS

We would like to acknowledge the contributions of all authors to this research. **Golam Mahadi** (first author) led the development of the Spot It! game project in collaboration with **Chany Zagury** and was responsible for designing the mathematical modeling. **Gazi Sabbir Ahammad** (second author) conducted field experiments, using the game with children in various settings, and collected empirical data. **Ahnaf Aiman Abdi** (third author) contributed to the refinement of the manuscript, utilizing AI-based tools to improve grammar and readability. All authors contributed equally to the conceptualization, analysis, and writing of this paper.

We also extend our gratitude to the children and educators who participated in this study, as well as to **Chany Zagury** for their collaboration on the game design. Finally, we acknowledge the use of AI tools (e.g., ChatGPT, Grammarly) for grammar and language refinement. The intellectual content, research, and findings presented in this paper are solely the work of the authors.

REFERENCES

1. Hatch, K.E., 2011. Determining the effects of technology on children. Senior Honors Projects, Paper 260. https://digitalcommons.uri.edu/srhonorsprog/260.
2. Panjeti-Madan, V.N. and Ranganathan, P., 2023. Impact of screen time on children's development. Multimodal Technologies and Interaction, 7(5), p.52. https://doi.org/10.3390/mti7050052.
3. Almaqhawi, A. and Albarqi, M., 2022. Effects of technology use on children's physical activity. Journal of Medicine and Life, 15(10), pp.1240–1245. https://doi.org/10.25122/jml-2022-0148.
4. Muppalla, S.K., et al., 2023. Effects of excessive screen time on child development. Cureus, 15(6), e40608. https://doi.org/10.7759/cureus.40608.
5. Rayhan, A., 2023. How technology is harming our children. CBECL's R&D Lab. DOI: 10.13140/RG.2.2.34234.57288.
6. Canonne, J-C., et al., 2022. Spot It! Mathematics through computer vision. J3eA, 21, p.2028. https://doi.org/10.1051/j3ea/20222028.
7. Heemstra, M., 2014. The mathematics of Spot It. The Journal of Undergraduate Research, 12(1), Article 7. Available at: https://openprairie.sdstate.edu/jur/vol12/iss1/7.
8. Horowitz, E., Sahni, S. and Anderson-Freed, S., 1993. Fundamentals of data structures in C++. Rockville, MD: Computer Science Press.

9. Spence, I. and Feng, J., 2010. Video games and spatial cognition. Review of General Psychology, 14, pp.92–104. DOI: 10.1037/a0019491.
10. Kaukoranta, T., Smed, J. and Hakonen, H., 2003. Role of pattern recognition in computer games.
11. Xiong, Z., Liu, Q. and Huang, X., 2022. Influence of digital educational games on preschool children's creative thinking. Computers & Education, 189, p.104578. https://doi.org/10.1016/j.compedu.2022.104578.
12. Hazegh, M., 2023. Characteristics of effective early childhood leaders: Emergence of relational leadership. In: I. Management Association, ed. Research Anthology on Early Childhood Development and School Transition in the Digital Era. IGI Global Scientific Publishing, pp. 862–888. https://doi.org/10.4018/978-1-6684-7468-6.ch043.
13. Kabir, S.M.S., 2016. Methods of data collection. In: Basic Guidelines for Research: An Introductory Approach for All Disciplines. 1st ed. Chittagong: Book Zone Publication, Chittagong-4203, Bangladesh, Ch. 9.
14. Woschke, T., Haase, H. and Kratzer, J., 2017. Resource scarcity in SMEs: Effects on incremental and radical innovations. Management Research Review, 40(2), pp.195–217. https://doi.org/10.1108/MRR-10-2015-0239.
15. Zagury, C., 2024. The Complete Ivrit Betil Set. Hebrew edition. Independently published.