

Exploring the potential of play-based learning interventions for academic success: An action research project on improving preschool students' number mastery

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Abstract. This action research project aimed to improve preschool students' number fluency through a six-week play-based learning intervention. The study collected data from students' GOLD assessment checkpoints and weekly formative assessments. The results showed a significant increase in students' number mastery (1-10 counting) from 40% to 60%, with even higher progress for those going into kindergarten on counting 1-20. The findings suggest that students of all backgrounds, including Special Education and ELL students, can achieve academic success with the right learning environment. The study highlights the potential of play-based learning interventions for enhancing early childhood education.

Keywords: Play-based learning, number fluency, number mastery, preschool

Introduction

The development of number fluency, which refers to the ability to understand and manipulate numbers effortlessly, is widely recognized as a pivotal aspect of early childhood education (Dehaene, 2011). It serves as a fundamental building block upon which various mathematical concepts and skills are constructed, thus laying the groundwork for future academic accomplishments. This significance is magnified in the context of rural public schools, where resource constraints often present challenges to delivering comprehensive educational experiences. Moreover, the diverse array of learning styles and cognitive capabilities within the student population further underscores the importance of nurturing strong number fluency.

In this study, a preschool teacher, also the lead author, embarked on an individualized action research endeavor to enhance the number fluency of her young learners. This undertaking was imbued with a strategic emphasis on two key components: firstly, the adept recognition of numbers, and secondly, the proficient ability to write numbers up to 20. The rationale behind this research stemmed from the belief that a solid grasp of number recognition and writing skills at an early stage could pave the way for greater mathematical competence in subsequent years.

Extensive literature highlights the critical role of early numeracy skills in children's mathematical development. A consensus among researchers, such as Clements and Sarama (2009), indicates that early number competency serves as a foundational pillar for later mathematical achievement. Empirical

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evidence by Duncan et al. (2020) further corroborates that early numerical knowledge is a significant predictor of later mathematical success, even after controlling for other cognitive factors and background variables. This is supported by the work of Ghazali (2020), who found that children who begin elementary school with a firm understanding of numbers and their meanings are better equipped to tackle more complex mathematical concepts. Moreover, studies by Borah (2022) and Ginsburg (2021) suggest that the ability to recognize and write numbers accurately is not merely a rote skill but is indicative of a child's understanding of number concepts and place value. The approach of this action research is also rooted in Vygotsky's social constructivist theory (Vygotsky, 1978), where the scaffolding of number writing and recognition is considered as a social process that can be enhanced through interaction with more knowledgeable others.

In light of this theoretical and empirical background, the action research undertaken by the preschool teacher aims to contribute to the field by not only enhancing pedagogical practice but also by providing further evidence of the long-term benefits of early number fluency. Through methodical observation and intervention, this study seeks to bridge the gap between theory and practice, thus enriching the academic discourse with practical insights into the development of number fluency in early childhood education.

Method and paradigm of research

According to Bennett et al. (2022), action research is an investigative method in which classroom teachers assess and enhance their teaching strategies to tackle specific issues in their classrooms. This method centers on identifying a particular problem, allowing the teacher to assume the role of a researcher and devise measures based on their discoveries. It is a rigorous inquiry process that bridges the gap between theory and practice, fostering critical thinking and results-based decision-making. Walker and Vu (2023) observed that many schools in the US have recently adopted the practice of incorporating teacher action research into the evaluation process to enable educators to take charge of their professional growth while learning from their colleagues' successes and struggles in the classroom.

As action research is concerned with change and participation and emancipation, mainly three paradigms of radical structuralist, interpretive and radical humanist in guiding action research. The interpretive paradigm is based on the fact that reality is created as a result of interpersonal interaction through talking-discussion -understanding- reconciliation. This paradigm based on anti-positivism and hermeneutic/practical interest guides action researchers especially in participatory and emancipatory action research due to being participatory and democratic as practitioner is involved as partners with expertise, not as subordinates (Burrell & Morgan, 1979; Gunbayi, 2020a). Thus this action research is guided by participatory action research based on interpretive paradigm as participatory action research which aims to improve effectiveness as well as enhancing the practitioner's understanding and professional development (encouraging practitioner practical deliberation and self-reflection) (Gunbayi, 2020b) and similarly play-based learning is a child-centered approach that focuses on the child's interests, needs, and abilities, while also recognizing the importance of play in child development.

In conducting this action research, a multifaceted approach was adopted. Various instructional methods and pedagogical techniques were explored to cater to the diverse learning needs of the preschool students. Through careful observation and ongoing assessment, the teacher gauged each student's individual progress, thereby tailoring the strategies to align with their developmental trajectories. Interactive and engaging activities were designed to not only make learning enjoyable but also to stimulate cognitive growth. These activities ranged from numeral-based games and exercises to creative tasks that encouraged the integration of numbers into everyday experiences. The research was underpinned by a cyclical process of planning, action, observation, and reflection. Periodic data collection enabled the teacher to track advancements, discern trends, and refine strategies accordingly. This iterative approach empowered her to continually adapt to the evolving needs of her students, thereby fostering a dynamic and responsive learning environment. In this particular action research project, the classroom teacher aimed to help develop her preschool students' number fluency through a

play-based learning intervention. Play-based learning, often used in early childhood education settings, is a teaching approach that involves using play as a means of educating young children. It is a child-centered approach that focuses on the child's interests, needs, and abilities, while also recognizing the importance of play in child development. Play-based learning encourages children to explore, experiment, and discover new things in a fun and safe environment.

Sampling

The curriculum and intervention programs used in the classroom have primarily focused on language and literature, with math activities integrated based on what is being covered in class. The Teaching Strategies GOLD assessment tool, which monitors the progress of children in key domains of learning, has shown that math and numbers are a lower area for all of her students. According to the GOLD guidelines, preschool students should be able to identify numbers up to 10 by the time they enter kindergarten, with a goal of identifying numbers through 20 for a solid foundation going into kindergarten. However, at the February checkpoint, only 46% of her students could identify numbers up to 10. Those students who were returning for another year all struggled with identifying numbers up to 6. As a dedicated teacher, she wanted to build a solid foundation on numbers for them so that they can carry that over to next year where they can add to their knowledge base. With that in mind, she started an individual action research project to help develop her students' number fluency

Researcher characteristics

The teacher, also the lead researcher of this project, has been teaching preschool at a rural public school in the Midwest in the US for five years, with 25 students ranging from age 3-5 years old split between two classes. Some of these students are in their first year of school and others are getting ready to go to kindergarten next year. Within these two classes, 07 students receive special education services, 01 is an EL student, and 02 are behavior students. According to the teacher, her students bring a wide range of learning styles and cognitive abilities to the classroom, with a lot of differentiation happening through large group, small group, and individual support.

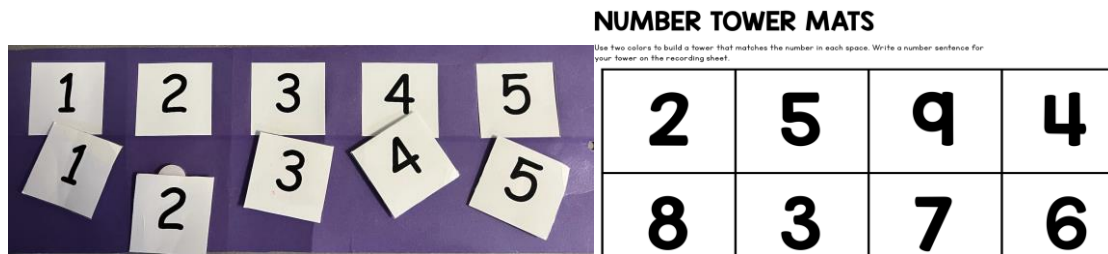
Intervention and data collection

Data collected for this study included two main sources. The first source was from students' GOLD assessment checkpoint before and after the 06-week play-based learning intervention. The second source was formative assessment of students' weekly progress. At the beginning of the intervention process between both the morning and afternoon classes, the teacher had 39% of her students not able to identify numbers to 10. She started to implement these interventions a week after she had collected all of the students' data pulled from GOLD. She did small group interventions 03 times a week during center time. Midway through this 06 week intervention she did a quick individual skills check to see where the students were at and if she needed to make changes to what she was doing.

The play-based learning intervention was designed to encourage children to engage in mathematical learning through playful exploration and application of concepts in a variety of contexts. To start, in whole group learning especially during calendar time, the teacher got students to talk more about the number of the month, and numbers on the calendar. To line up for lunch, she had them come up and write a number she told them on the whiteboard. When lining up for breakfast and lunch she would write a number on their dots and tell them to find that dot to line up on. According to the teacher, adding little things into their day would benefit along with small group skills groups because children engage in spontaneous exploration and application of mathematical concepts in their daily activities and play, well before they start attending school. Moreover, their understanding of mathematics can be intricate and advanced. She also put math manipulatives into their center areas, as well as the sensory bin because research shows that young children learn best through play, so adding in math-based manipulatives and letting them explore is a great benefit for them.

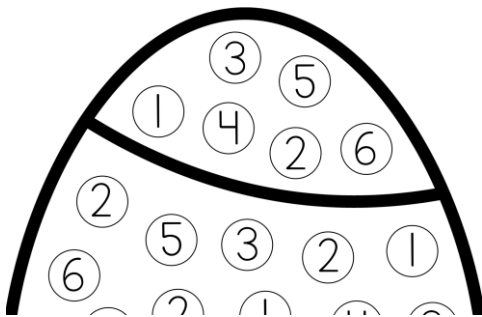
For small groups, she looked at her beginning data and split them into groups based on where they were at in GOLD. The teacher tried to pull each group 2-3 times a week depending on the needs of the students. The activities that they did within these groups range based on cognitive ability. For her lower groups they started out simple just by talking about the numbers and matching and continued to build on those skills. The higher ability groups would play dice games. She had a higher skills group that worked on writing our numbers. During this time she would not only use paper pencil but, make it more fun by using shaving cream, paint, sugar... etc. to practice writing numbers. This group was pulled 1 to 2 times a week.

During the 06-week intervention, two of the days were number identification activities. The activities were different each day, and oftentimes were repeated throughout the 06 weeks. Some of these activities included flipping a playing card and finding that number on the paper and coloring it in. Another activity was counting the number of dots on a card and identifying the number and placing a clothespin on that number. For students that needed more practice they would do activities on just matching numbers. The teacher had a few job boxes where they would match the number on a stick and place it in the hole that was labeled with that number, or just simply match the number. Below are a few examples of the interventions.

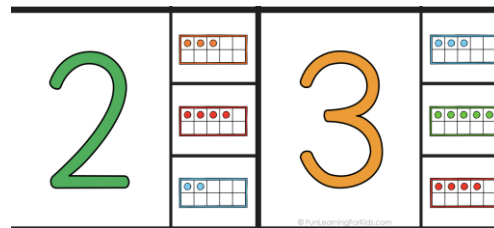


Match and say the number

Build the number with unifix cubes



Draw a playing card and color the number



One example of a number clip card

Figure 1. A few examples of the interventions

On fun Friday, students got to pick groups and they would play a game. A lot of her students did not play board games at home and she wanted a fun way of learning for students, not only were they working on number identification, but they also worked on turn taking, and social skills. Games that were played were, UNO, Hi Ho Cherry-O, Matching Game, and Shots and Ladders.

Ethical procedures

Scientific research ethics were followed at all stages of the research. A review board approval of the research was obtained from the University's Institutional Review Board (IRB Approval Number: 091421-1) before the project started.

Rigor

The followings were carried out to increase the rigor of our research. The study's internal validity or credibility is vigorous, attributed to the use of the GOLD assessment checkpoints, which provided a comparative measure of student capabilities pre-and-post the six-week intervention. Additionally, the credibility is enhanced by the integration of formative assessments, offering a dynamic view of student development on a weekly basis. While these rigorous methods underpin the study's internal rigor, the external validity, or transferability, may be somewhat constrained due to the nature of action research involving a specific educational context and demographic. However, the comprehensive documentation and transparency of the intervention steps lend themselves to potential adaptation and application in similar settings, facilitating a degree of transferability. The research's internal reliability or confirmability is exemplified by the uniformity and systematic approach in data collection, as well as the teacher's meticulous observations. The adaptability in the instructional approach, informed by ongoing assessments, illustrates a commitment to tailoring educational strategies to meet the evolving needs of students, which also supports the external reliability or dependability of the research. This structured yet flexible methodology suggests that the findings could be replicated and are dependable across similar educational scenarios, assuming similar conditions and constraints (Maxwell, 2012; Morris & Paris, 2022)

Findings

Data collected for this study included two main sources. The first source was from students' GOLD assessment checkpoint before and after the 06-week play-based learning intervention. The second source was formative assessment of students' weekly progress. At the beginning of the intervention process between both the morning and afternoon classes, the teacher had 39% of her students not able to identify numbers to 10. She started to implement these interventions a week after she had collected all of the students' data pulled from GOLD. She did small group interventions 03 times a week during center time. Midway through this 06 week intervention she did a quick individual skills check to see where the students were at and if she needed to make changes to what she was doing.

During the 06-week intervention, the teacher also collected data weekly to see the progress the students were making. She took notes on her students' progress and also kept notes on students who were still struggling, so if she needed to change up her groups she could do that. During the 06 weeks, she changed groups up twice, once 02 weeks in and then again about 02 weeks later. Once it was time for a skill check, she would pull the students individually and do a quick skills assessment using flash cards. She would then mark down on their individual student skills paper and upload that into GOLD for the checkpoint. When she updated each student's assessment paper she liked to use different colors for each checkpoint so she could compare to where they were previously.

The results showed a significant increase in number mastery (counting 1-10) from 40% to 60% after the play-based learning intervention. This increase was particularly notable for students entering kindergarten, who showed a high level of improvement in counting up to 20. Figure 2 below provides a summary of the data.

Number Identification

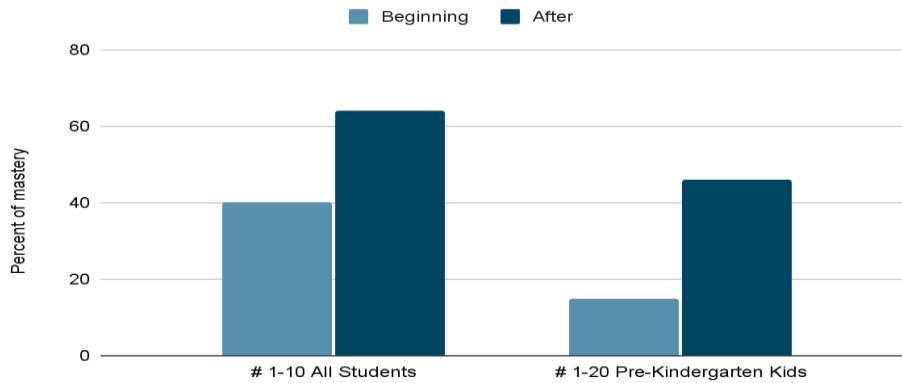


Figure 2. *Students' progress before and after the intervention*

Discussion and Reflection

According to the teacher, even before delving into the data analysis, it became evident that significant strides were being taken in the realm of skill development, even prior to conducting formal skills assessments. From observing her students in various classroom activities, the teacher stated it was apparent that their levels of confidence were steadily increasing, especially when tasked with identifying numbers within diverse contexts.

However, it was only when she conducted individual skills assessments on each student and meticulously gathered official data that she was able to gain a comprehensive understanding of the true efficacy of the interventions implemented. At the outset of the intervention process, a mere 39% of her students displayed the ability to identify numbers ranging from 1 to 10.

A closer examination of the data presented in Figure 2 underscores the remarkable transformation achieved over the course of the 06- week intervention period. The numbers speak volumes: following the completion of the intervention, a significant 64% of her students demonstrated proficiency in identifying numbers within the 1 to 10 range. This increase in success rates is a testament to the effectiveness of the intervention strategies employed.

What stands out most impressively from this progress is the notable advancements achieved by her students who are on the brink of entering kindergarten. At the initiation of the 06- week intervention period, this subgroup exhibited a mere 20% proficiency in identifying numbers up to 20. By the conclusion of the intervention, this percentage more than doubled, with an encouraging 45% of these students showcasing the ability to identify numbers up to 20.

While this may not represent a majority, it is crucial to recognize the context in which this progress was achieved. Given the baseline data from the commencement of the academic year, the strides made are undoubtedly substantial. This transformative journey highlights the power of targeted interventions and their potential to drive significant enhancements in students' skill acquisition and overall learning trajectory.

When analyzing the data pertaining to students who are slated to return for an additional year of preschool, it becomes evident that they possess a solid foundational grasp of number identification. This proficiency allows them to confidently recognize numbers up to 20 even before entering kindergarten. Given the continuity of the educational intervention, the teacher holds the conviction that their progress would continue to flourish, culminating in further advancements by the culmination of the school year—a mere 6½ weeks away.

The findings extracted from this project yield a resounding affirmation: all students possess an innate capacity for learning, irrespective of their classification as Special Education, English Language Learners (ELL), or typical learners. This assertion underscores the pivotal role played by an appropriate and conducive learning environment. Yet, amidst these encouraging outcomes, a paramount inquiry persists: how can a teacher facilitate a higher level of consistency in students who are grappling with or intermittently struggling with number identification?

The persistent challenge presents itself with three kindergarten-bound students—two duly identified as Developmentally Delayed (DD) and one categorized as having Specific Language Impairment (SLI). Despite diligently incorporating an array of interventions and daily number identification activities since the inception of the academic year, the proficiency gap remains unresolved for these three individuals. In light of this predicament, a potential avenue emerges: deconstructing the learning process into more elementary interventions. These interventions could be administered on an individual basis or within the context of a partnership with a peer possessing a heightened aptitude.

Implications

The implications derived from the findings of this action research project hold significant potential for shaping and enhancing the landscape of early childhood education in multifaceted ways:

- **Effective Integration of Play-Based Learning:** The study's revelation of the efficacy of play-based learning interventions in bolstering preschool students' number fluency underscores a paradigm shift in pedagogical practices. Educators should strategically embed play-based activities into their curriculum, utilizing toys, games, and interactive experiences that foster a deep understanding of mathematical concepts. This approach not only engages young learners but also establishes a strong foundation for future academic achievements.
- **Empowerment through Formative Assessment:** The study's emphasis on formative assessment as a tool for real-time monitoring of student progress offers educators a blueprint for cultivating personalized learning pathways. Regular assessment and timely feedback enable educators to identify students' strengths and areas needing improvement, allowing for adjustments in instruction methods. This dynamic process empowers educators to cater to each student's unique learning trajectory, leading to more substantial educational growth.
- **Inclusivity and Equitable Education:** The study's identification of the potential for academic success across diverse student backgrounds emphasizes the paramount importance of inclusive and equitable education. Educators are encouraged to create a classroom environment that accommodates learners with varying needs, ensuring that students with disabilities, special education requirements, or English Language Learners (ELL) receive the necessary support to thrive. This approach not only enriches the learning experience but also promotes a culture of respect and understanding among students.
- **Tangible Learning through Manipulatives:** The study's endorsement of the efficacy of manipulatives and hands-on materials as tools for conceptual exploration represents a reimagining of teaching methodologies. Educators are prompted to supply students with a myriad of tactile materials that foster active learning. Through tactile engagement, children can grasp abstract mathematical ideas more concretely, promoting a deeper understanding and retention of concepts.

- Customized Learning through Small Group Instruction: The study's recognition of the value of small group instruction as a means to facilitate preschool students' academic achievement reinforces the significance of tailored education. Educators should establish small-group settings where personalized instruction can occur. Such an approach permits educators to identify individual needs and design targeted interventions that address specific learning gaps, ensuring that each child receives the guidance they require for optimal growth.

In essence, these implications collectively advocate for a transformation in early childhood education that embraces dynamic teaching strategies, inclusivity, assessment-driven adaptations, and a renewed focus on practical engagement. The research encourages educators to adopt a multifaceted approach that fosters holistic growth, acknowledging the unique attributes of each learner and preparing them for a future marked by academic prowess and personal enrichment.

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Ethical approval

In the writing process of the study titled “**Exploring the potential of play-based learning interventions for academic success: An action research project on improving preschool students' number mastery**”, the rules of scientific, ethical and citation were followed; it was undertaken by the authors of this study that no falsification was made on the collected data, “Journal Action Qualitative & Mixed Methods Research [JAQMER] and Editor” had no responsibility for all ethical violations to be faced, and all responsibility belongs to the authors and that the study was not submitted for evaluation to any other academic publishing environment.

Ethics committee approval

A review board approval of the research before the project started was obtained from the University's Institutional Review Board (IRB Approval Number: 091421-1).