Playfully Scientific: Teachers' Perspectives on Toy-Based Pedagogy Supported by AI for Middle-Stage Science and Mathematics Learning

Asmit Kumar Sahoo[1], Rasmirekha Sethy[2], Chinthakuntla Mahendar[3], Poulastya Mahananda[4], Shishu Pal Singh[5], Sraban Kumar Bag[6], Dipanshu Sharma[7*]

[1] Research Scholar, Department of Education, Regional Institute of Education (NCERT), Utkal University, Vani Vihar, Bhubaneswar, India. Email: asmitsahoo95@gmail.com ORCID: https://orcid.org/0009-0006-8715-5583

[2] Professor, Department of Education, Regional Institute of Education (NCERT), Bhubaneswar, India. Email: drrasmirekhasethy@gmail.com ORCID: https://orcid.org/0009-0008-8566-2084

[3] Assistant Professor, Department of Education in Science & Mathematics (DESM), Regional Institute of Education, NCERT, Bhubaneswar, India mahendar02@ncert.nic.in ORCID: https://orcid.org/0000-0003-4295-303X

[4] Assistant Professor, DSSE, Nalini Devi Women's College of Teacher Education, Bhubaneswar India, poulastyamahananda@gmail.com ORCID: https://orcid.org/0009-0002-9266-3401

[5] Assistant Professor ESD, NIE, NCERT, New Delhi India. Email: drspsingh@ncert.nic.in ORCID: https://orcid.org/0009-0007-5814-0566

[6] Assistant Professor, Department of Education, Sambalpur University, Jyoti Vihar Odisha, India. Email: sraban.bag@gmail.com ORCID: https://orcid.org/0009-0008-5024-3242

[7*] Assistant Professor, Department of Education, Regional Institute of Education (NCERT), Bhubaneswar, India. Email: drdipanshusharma@gmail.com ORCID: https://orcid.org/0009-0007-9920-0166

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ABSTRACT:

This chapter extends teachers' perspectives on toy-based pedagogy as an innovative approach to improve learning outcomes in middle-stage science and mathematics, while repositioning toy-based pedagogy within the artificial intelligence era of education. Though toy-based pedagogy resonates well with experiential, play-based learning highlighted in NEP 2020, this revision further underscores how AI-enabled tools like intelligent tutoring systems, adaptive learning environments, and data-driven analytics can support, personalize, and scale up toy-based instruction. Drawing from reported teacher experiences, the chapter argues that AI can help select toys that are age- and concept-appropriate; generate adaptive prompts during play; capture observational and assessment data; and provide actionable insights for differentiated instruction. Findings suggest integrating AI with toy-based pedagogy strengthens conceptual understanding in science and mathematics toward addressing alternative conceptions more effectively while making toy-based learning responsive to diverse learner needs in an AI era. The paper analyses standpoint of 25 teachers from different schools on opportunities, innovations, merit and challenges of merging toy-based pedagogy assisted by AI in classroom learning. Qualitative data analysis using thematic analysis method

is used in the paper. Teachers are incorporating toys into their teaching methods to improve cognitive, social, and emotional development in student. The chapter concludes with implications for teacher education, curriculum design, and policy by calling for deliberate integration of AI-assisted pedagogical tools alongside toy-based approaches in middle-stage science education. It was found that proper training, workshops, concept aligned framework for designing toys and teacher awareness are necessary. Teachers can incorporate toys in their class to improve students' attention, make classroom more engaging by providing joyful experiences.

Keywords: AI assisted Toy Based Pedagogy, AI in classroom evaluation, Competency Based Learning Outcome, Alternative Conceptions, Joyful Learning, Teacher awareness.

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1. Introduction

Mathematics and science education at the middle stage has increasingly been expected to address the balance of conceptual depth, conceptual change (conceptual transformation, addressing alternative conceptions), and engagement in an era of teaching and learning transformed by artificial intelligence. Toy-based pedagogy, which makes use of children's natural joy of play and toys as instructional tools, has been recognized as an effective approach for experiential hands-on learning that is in line with NEP 2020's vision on holistic education and competency-based learning. The central theme of this book - Transforming Mathematics Education in the Artificial Intelligence Era and Its Impact on Education - requires explicitly placing TBP within AI-driven transformations in education rather than treating it as just another play-based approach.

AI in education (AIEd) has seen an exponential increase over the last decade, more particularly through intelligent tutoring systems (ITS), adaptive learning platforms, and AI-driven analytics tools that predict student performance and provide actionable insights for educators. ITS can detect understand and react to learner progress symptoms of difficulty and error customize difficulty levels so as to create an optimal path for learning. Systematic reviews indicate that the effects of ITS on K–12 learning and performance are mostly positive though their effectiveness depends on good pedagogical features such as immediate feedback guided practice adaptivity plus matching tools with appropriate learners in suitable contexts. Academic performance gains from 15% up to 25% have been reported for AI-driven adaptive learning systems along with improvements in learner engagement by 40% particularly within STEM fields though challenges relating to technical infrastructure and teacher readiness still exist.

The Toy-based pedagogy envisioned by India's National Education Policy 2020 emphasizes active engagement, exploration, discovery-based learning creativity critical thinking multidisciplinary understanding. It is best suited for addressing alternative conceptions in science and mathematics by allowing students to manipulate concrete objects test their hypotheses reconstructing their understanding through play. But without an explicit connection to AI, it would be TBP may seem disconnected from the book's focus on AI in this era

The integration of toy-based pedagogy in science classrooms represents a transformative approach to teaching and learning, aligning with the principles of experiential learning and the National Education Policy (NEP) 2020. NEP 2020 advocates for a holistic, engaging educational experience, promoting critical

thinking, creativity, and problem-solving skills. Toy-based pedagogy, based on experiential learning, connects theoretical concepts to real-world applications, making science education more accessible and meaningful. The study investigates the use of toy-based pedagogy in transforming education systems, in line with the National Education Policy (NEP) 2020 emphasis on holistic and experiential learning. It emphasizes the advantages of toy-based approaches for fostering creativity, critical thinking, and multidisciplinary learning. The study also discusses how toy-based pedagogy affects curriculum design flexibility, inclusive education, and technology integration. It advocates for stakeholder collaboration to fully realize the potential of toy-based approaches to educational reform. (Pandey 2024).

Inclusive learning environments can foster curiosity, creativity, collaboration, and teamwork by incorporating indigenous and culturally appropriate toys. (Sharma 2020) Experiential learning in science education fosters curiosity, creativity, collaboration, and teamwork. Inclusive learning environments, including indigenous toys, promote teamwork. Teachers play a crucial role in designing and facilitating activities aligned with curriculum objectives and student needs. (Kolb 1984) This qualitative study, which gathers data from 20 teachers, aims to investigate the practical application of toy-based pedagogy in science classrooms.

It aims to better understand teachers' perspectives, challenges, and best practices, adding to the growing body of knowledge on innovative pedagogical strategies in education. By doing so, it hopes to inform policy and practice, resulting in a more engaging and effective science education environment.

Lee and Hammer (2011) highlight the positive effects of gamification, stating that games develop problem-solving skills through complex rules, encourage exploration, and provide tailored challenges, while also emphasizing the emotional area, including powerful emotions like pride, joy, optimism, and curiosity. Toy-based pedagogy employs playful learning strategies to facilitate cognitive, social, and emotional development in children. This educational approach emphasizes the use of toys as primary learning tools, allowing students to explore concepts firsthand. A growing body of research shows that incorporating toy-based pedagogy into classrooms improves learning outcomes across multiple domains.

Research Questions:

1. What is the status of awareness and understanding of Toy-based pedagogy (TBP) among school teachers, and how does this awareness influence their teaching practices and student engagement?
2. What are the training programmes, workshops or seminars, the teachers have attended on Toy-based pedagogy?
3. What is the name of the chapters, concepts, sub-concepts and theories that were discussed using Toy-Based Pedagogy? And name the specific toys used for the concepts.
4. What is the impact of TBP on critical thinking, problem solving, motivation and creativity of the learners?
5. How can Toy-Based Pedagogy be used for improving competency-based learning outcome and conceptual understanding by reducing the alternative conceptions of the students?
6. What feedback have you received from students regarding their learning experiences with Toy-based pedagogy?
7. What challenges, opportunities and possibilities did you find in implementing Toy-based pedagogy more effectively?

Objectives of the study:

1. To study the awareness of school teachers on integration of toy-based pedagogy in classroom
2. To identify the training programmes, workshops or seminars that are arranged for teachers on toy-based pedagogy
3. To study the impact of toy-based pedagogy on critical thinking, problem solving, motivation and creativity of students

4. To study the impact of toy-based pedagogy on Alternative conceptions and Competency-based learning outcome in science classrooms
5. To study the effectiveness and position of learners on integration of toy-based pedagogy
6. To study the challenges and possibilities in integrating toy-based pedagogy in classrooms

Statement of the Problem:

The present study can be stated as **"Playfully Scientific: Exploring Teachers' Perspectives on Toy-Based Pedagogy for Enhancing Learning Outcomes in Middle Stage Science and Mathematics"**

Delimitation of the Study

- The present study was delimited to science and mathematics teachers of middle and secondary stages of central and state board schools of state of odisha.

Review of relevant literature

Pedagogy of toys in the AI era: A hybrid framework for playful learning supported by AI

This chapter redefines TBP as toy-based pedagogy supported by AI, which is a hybrid approach in which AI tools are used to enhance rather than replace play-based experiential learning. Specifically, AI can support TBP through four interrelated pathways.

First, AI can recommend and design toys that align with learning outcomes, age, and conceptual requirements. Physical play objects have already been enhanced with intelligent features to support cognitive development through the use of smart toys and AI educational toys in introducing basic STEM concepts in a playful way (The Little Learners, n.d.). For instance, an app powered by artificial intelligence can analyse photos of toys to determine educational benefits and provide age-appropriate recommendations. It can also work across several languages to make toy-based learning accessible to various learners (The Little Learners, n.d.).

Second, AI can provide adaptive prompts and scaffolding during toy-based activities in real time by generating hints, questions, or tasks based on student responses. Intelligent tutoring systems (ITS) have proven their ability to detect and understand a learner's progress as well as to monitor difficulties and errors so that they could adjust task difficulty for developing an optimal learning path (Letourneau et al., 2025). These are some examples of pedagogical features embodied by such systems: immediate feedback and practice under guidance which are critical for effective learning outcomes (Letourneau et al., 2025).

Thirdly, AI can capture data from observations and quizzes as well as performance during toy-based tasks to analyse it help teachers identify misconceptions track progress refine instruction through learning analytics. Data-driven instruction best practices use assessment data to drive instructional decisions and support learners (Texas Education Agency, 2025; U.S. Department of Education, Institute of Education Sciences, n.d.). Analytics tools driven by artificial intelligence may predict student performance while providing educators with actionable insights thus making it possible for alternative conceptions in science and mathematics to be identified more systematically (Letourneau et al., 2025).

Finally, AI can support differentiation and personalization by grouping students adjusting task difficulty suggesting next steps after toy-based activities making TBP more responsive to diverse learners. Gains in academic performance of 15–25% have been achieved with improved learner engagement by up to 40% through the use of AI-driven adaptive learning systems in STEM fields even though challenges such as technical infrastructure and teacher readiness remain (Yuensook et al., 2025).

Recent research on AI-integrated smart toys shows that AI can support cognitive, emotional, and motor development in young learners. This highlights a growing intersection between AI and physical play objects (OUCI, n.d.). The literature

on AI in children's toys also reveals specific ethical, legal, and developmental issues that need to be considered as AI becomes integrated into children's everyday learning environments (Martyn et al., 2023). These issues include data privacy, algorithmic bias, and the potential for over-reliance on technology—all things teachers will have to consider when integrating AI with TBP (Letourneau et al., 2025; Yuensook et al., 2025).

This chapter focuses on teachers' perspectives regarding TBP in middle-stage science and mathematics instruction while making an explicit connection to AI-assisted teaching and learning. It poses the following questions: How can AI technologies support, enhance, and scale toy-based pedagogy in middle-stage STEM education? What are teachers' views on the feasibility, benefits, and challenges of integrating AI with TBP? In addressing these questions, this chapter contributes to an emerging conversation about how experiential play-based pedagogies might be transformed in the age of AI while retaining their human-centered embodied character (Letourneau et al., 2025; Redshine, n.d.).

Rationale of the Study:

Toy-based pedagogy is an innovative technique in education that enhances learning outcomes across all stages. It encourages cognitive development by improving problem-solving skills and creativity. Toys foster social and emotional development by encouraging peer collaboration and communication. This prepares students for future educational and professional settings in which they will need to collaborate and solve problems together. (Gallagher & O'Reilly 2020).

Toy-based learning is consistent with developmental theories, such as Piaget's theory of cognitive development, which emphasizes active manipulation of the environment. Use of toy-based methods enhances understanding of abstract concepts. It also caters to a diversity of learning methods, including kinesthetics learners who benefit from physical activity during learning. This technique brings an inclusive classroom atmosphere in which all students can excel. TBP promotes imagination and inventiveness, as children who play with educational toys show better investigative skills and a desire to learn new ideas.

Thomson et al. (2022) found that use of TBP methods upgrade students' insight of abstract conceptions by allowing them to visualize and interact with materials.
Toys make learning more captivating, increasing student engagement. Hassinger-Das et al. (2018) discovered that letting children to use toys and games during classroom activities improves absorption among students making a joyful and attentive learning environment.
Toy-based pedagogy is an effective method for enhancing creativity, imagination, motor development, social and emotional development, active learning, and academic achievement. Teachers play an important role in implementing this approach by incorporating toys into the curricular practices, selecting resources that are aligned with learning goals, promoting cooperation, and tracing student progress. Teachers can help students prepare for scholastic achievement and lay the foundation for future success by inculcating strong foundational skills in them. Teachers can assist their learners in improving the skills and knowledge they require to succeed in the world by cultivating positive relationship among student teachers. (Lone and Kour 2024) Toy-based pedagogy fosters children's creativity and imagination through various art and craft activities, encouraging them to investigate multiple possibilities and solutions. This approach fosters innovation, making it necessary in today's rapidly changing world. (Field 2022).
Toy-based pedagogy is a transformative approach to teaching children with autism spectrum disorder (ASD) that uses engaging, multisensory experiences. This approach encourages socialization, communication, cognitive development, and emotional well-being. It promotes personalized learning, which improves academic performance and life skill development.

Teachers at Takshashila Vidyapith use various toys to develop children's fine motor skills and are interested in government initiatives for Toy Based Pedagogy training. The school has a toy corner and toys are age and culturally appropriate. Teachers believe toys can promote learning in Foundational Years and are willing to participate in workshops to learn about Toy Based Pedagogy. (Koch and Sharma 2023)

Toy-based pedagogy uses interactive and creative learning tools to make learning more enjoyable and successful. This research compares traditional methods with toy-based approaches, revealing that toys significantly impact academic performance, particularly in language skills, problem-solving, and concept comprehension. They also foster active engagement, creativity, and curiosity, contributing to a comprehensive educational experience. The findings underscore the importance of fun learning methodologies in foundational education for personal and professional growth. (Manju 2025)

Toy-based learning aligns with developmentally appropriate practices (DAP), promoting educational practices based on child development knowledge and respecting individual interests and developmental levels. (National Association for the Education of Young Children NAEYC 2020)

The National Curriculum Framework for School Education (NCFSE) 2022, based on The NEP 2020 principles emphasize child-centred learning, which includes play and exploration. It emphasizes toys as essential tools for active learning, encouraging problem-solving, creativity, and collaboration. The framework encourages educators to provide stimulating environments in which children can engage with toys and play-based activities. (NCFSE 2022)
The National Curriculum Framework for Foundational Stage (NCF-FS) 2022 in India encourages toy-based pedagogy for children aged 3 to 8, with an emphasis on play, language acquisition, and communication skills. It employs educational toys like blocks and puzzles to foster curiosity, creativity, and overall development. The framework also promotes inclusivity, ensuring equal opportunities for all children, including those with special learning needs. (NCF FS 2022)

NCERT has issued guidelines to boost play-based learning approaches in the classroom, stressing the role of instructive toys in endorsing evolving indicators such as language attainment and societal skills. The guiding principle aims to create a comprehensive, hands-on learning situation that quarters diverse learning panaches and impart students a sense of belonging. They promote partnership between instructors and parents in the selection of fitting toys, as well as expert development programs that prepare teachers with the skills required to effectively implement toy-based strategies. (NCERT, 2022). Teachers can create energetic learning surroundings that promote intellectual, social, and emotional development in students. However, successful operation necessitates coordinating toys with educational goals and managing classroom dynamics. Teachers' comprehension and mastery of TBP is critical for navigating these challenges.

By leveraging occasions like increased student appointment and upgraded learning outcomes, teachers can outline better classroom instructions that enhance education excellence and prepare children for future learning involvements. Therefor the investigator wants to study the existing place of teachers from several schools on chances and challenges in fit in the TBP in classroom.

2. Methodology and Design: Qualitative research was followed with thematic explorative analysis method.

Population and Sample: Out of all the primary and secondary schools in Odisha, Population of the study was the science and mathematics teachers of primary and secondary schools of state of odisha. For the present study researcher used convenient sampling technique. Fifteen schools were selected conveniently by the investigator. Thirty teachers (one science and one math teacher each from one school) were selected out of the fifteen schools.

Instruments: Self-made open-ended questionnaire for the teachers were used, Research papers, review articles and Journal papers available in research gate, Google scholar, ERIC and SCOPUS

Analysis and Interpretation of Data:

- The present study aims to explore the perceptive of middle and secondary stage teachers towards inclusion on TBP in science classrooms. The researcher used self-made questionnaire for science and math teachers of middle and secondary stage. The researcher gathered the data and interpreted using thematic analysis approach**.**
- **Awareness of middle and secondary stage science and mathematics teachers on integration of TBP in classroom**
- More than 80 percentage teachers are aware of TBP integration in classroom. They know it as an innovative pedagogical practice developed by NCERT and promoted through DIKSHA modules and other platform like you tube channel of NCERT and different training session and workshops. More than 15 percentage teachers have got to know about the pedagogy from their colleagues and friends. Although many of the teachers are aware of the pedagogical approach, there were only 20 percentage teachers who never used the approach and 15 percentage never heard of the term TBP.
- **Attending training programmes, workshops or seminars on TBP**
- Only 10 percentage teachers out of all have received formal training on TBP. One from a workshop programme organised at Regional Institute of Education Bhubaneswar and one from NISHTHA FLN training.
- The rest 90 percentage teachers have either not received any formal training or got some lessons informally from internet or other sources on their own. There is a need of structured training programmes and workshops to be organised at block and cluster level on TBP.
- **Chapters, concepts, sub-concepts and theories taught Toy-Based Pedagogy and the specific toys used for the concepts**
- More than 60 percentage teachers have used different toys to teach various science and mathematics concepts. Toy-based pedagogies include toys such as card board, puppet, puzzle, and geometry shapes and sizes are used in various chapters to teach various science concepts. For example, in the chapter on states of matter, balloons are used to demonstrate gas expansion and compression. Force, friction, and diversity are discussed using various toys, such as pull, push, and kick. Human physiological models are also used to discuss human anatomy in biological science. Physical science chapters such as force and motion, acceleration and friction through car jeep, and electricity through basic bulbs and wire toys were effectively taught. While formally applied in teaching, toy-based pedagogy can be a valuable tool for understanding various concepts through fun filled and joyful environment.
- **Role of toys in making classroom engaging, active and learner-centric for the teachers**
- Around 70 percentage teachers opine that toys play a crucial role in making classes more engaging, active, and learner-centric. They transform abstract concepts into tangible experiences, allowing students to see, touch, and experiment with ideas directly. This approach is effective for assessment, joyful learning, and experiential learning. Students are enthusiastic about the class and eager to learn new concepts. Toys are especially helpful for slow learners and can diversify their learning abilities and strengthen cognitive skills. They are beneficial for all students, as they are effective for concept building and abstract thinking. Overall, toys are beneficial for all students, as they encourage active participation and foster a sense of teamwork. But there are more than 20 percentage teachers do not have such opinion regarding TBP.
- **Role of toys in improving students critical thinking and problem-solving abilities when using toys in lessons**
- More than 65 percentage of teachers opined that Toy-based pedagogy can significantly enhance students' critical thinking and problem-

solving abilities. By interacting with toys, students naturally ask questions, make predictions, and test outcomes. This approach increases students' interest and creativity, leading to a deeper understanding of concepts and the ability to solve questions from their daily lives. Toys create more fun and curiosity among students, encouraging active participation and exploration of the topic. The main difference is that students who use toys for teaching experience their creativity level to increase, leading to a deeper understanding of the concept. They can also search for real-life situations, leading to more creative solutions. This type of pedagogy can lead to more engaging and effective learning experiences for students.

- **Role of Toy-Based Pedagogy in improving the Competency based learning outcomes of the students**

- More than 70 percentage teachers were of the opinion that Toy-based pedagogy enhances cognitive, social, and emotional development in students through practical, experiential teaching methods. It improves problem-solving skills, conceptual understanding, and self-confidence. This method is beneficial for slow learners and students with special needs. Toy-based learning is effective in enhancing participation, cognitive skills, and motivation. It can be applied in real-world applications and is a learning by doing method, making it a valuable tool for future generations. 20 percentage teachers were neutral about the effectiveness of TBP.

- **Role of TBP on reducing Alternative conception**

- Around 70 percentage of the teachers are of the opinion that Toy-based pedagogy helps students understand complex concepts easily and memorize them for longer. It can be improved through experiential learning methods, immediate feedback, and active group discussions. Toys imitate students' minds, fostering critical thinking and knowledge exploration. By promoting this approach, complex concepts can be simplified, reducing misconceptions. Implementing toy-based pedagogy in schools can improve conceptual understanding and reduce students' alternative conceptions, making it a valuable tool for teaching.

- **Feedback of Students on integration of TBP in classroom**

- 45 percentage teachers describe a positive experience of students with Toy-Based Pedagogy in classroom, where students are more attentive and engaged. Although the implementation has not been formalized yet, it is expected to make students feel confident in expressing their ideas. The students feel like junior scientists and are happy with the teaching-learning process. And more than 50 percentage teachers are yet to take any formal feedback from the students.

- **Challenges and limitations faced by teachers in integrating TBP in classroom**

- Many teachers believe that TBP is a time-saving and cost-effective approach to teaching, but it can also be time-consuming and costly. It requires careful planning and management to ensure effective implementation. The use of toys as characters can be distracting, and selecting appropriate age-appropriate toys can be challenging. Matching toys to different topics and creating superficial imagination can also be challenging. There are limitations to this approach, such as class size not being suitable for limited toys and timing constraints. Large class sizes may not allow for the growth of students, and the total curriculum should not be completed within a limited timeframe.

- **Additional support and resources that can be given to effectively induce TBP**

- 50 percentage teachers believe that toy-based learning can be implemented in schools through various methods, including incorporating low-cost materials, student participation, and integrating ICT. Schools can encourage teachers to adopt this approach by providing training, organizing teacher meetings, and encouraging self-motivation. Teachers should be given extra priority in preparing toys and providing resources for developing TLM. Innovations in toy-based learning include using handmade toys, creating chapters based on proper toys, and incorporating events like

PANCHATANTRA, NUKAD NATAK, or DRAMA. State governments should use a concept-wise framework for toy-based pedagogy, and schools should frame their syllabus accordingly.

3. Results

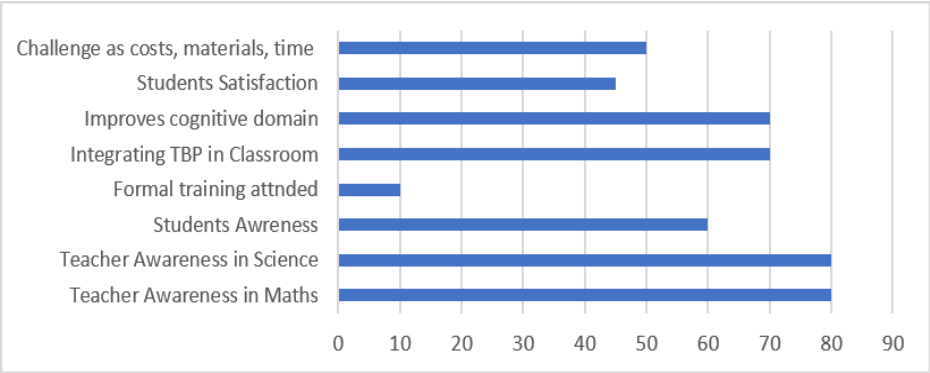
The study reveals that while most teachers are aware of toy-based pedagogy (TBP) through informal channels, a few have participated in formal training programs. TBP, which uses toys like puppets and puzzles, improves student engagement, creativity, and competency-based learning outcomes. However, challenges like cost, time constraints, and lack of age-appropriate toys hinder its effective integration. Despite these obstacles, student feedback suggests that formal integration and structured feedback mechanisms could enhance TBP's effectiveness. Continual training, better resource allocation, and curriculum alignment with TBP could strengthen pedagogical practices and improve educational outcomes.

- More than 80 percentage of the teachers are aware of TBP through NISHTHA modules on FLN, You tube, internet or from colleagues
- Only 10 percentage teachers have attended formal training on TBP such as training programmes conducted at RIE, NCERT, Bhubaneswar and NISHTHA FLN training. Most of teachers have informally learnt about TBP through internet.
- 60 percentage teachers have used TBP such as puppets, puzzle, ludo, cardboard, ballons and human toys, jeep toys to discuss concepts such as force, friction, geometry, human anatomy and chemistry
- 70 percentage teachers are of the opinion that TBP helps in improving learners' engagement, participation, and apart from it TBP helps to foster creativity, problem solving skills through hands-on experience in a joyful learning environment.
- 65 percentage teachers believe that use of TBP has improved competency-based learning outcome among learners through visualising the phenomenon through toys.
- 70 percentage teachers are of the opinion that TBP has reduced the alternative conceptions through providing experiences inside the classroom.
- 45 percentage teachers feel that many students are satisfied and happy by learning from TBP. But formal integration and feedback is required
- 50 percentage teachers believe that cost, time, proper management, framework for concept aligned toys, and age-appropriate toys needs to be designed by state government.
- Regular training, locally available toys, chapters aligned with toys, Nuked Natak and drama should be promoted for awareness on integrating TBP across state can be done.

Table 1. Teachers' Perspectives on Integrating Toy-Based Pedagogy in Classrooms

Theme	Sub-Theme	Codes	Major Findings
Awareness of TBP	Sources of Awareness	NISHTHA, YouTube, Internet, Colleagues	80 percentage teachers are aware of TBP through NISHTHA modules on Foundational Literacy and Numeracy (FLN), YouTube, the internet, and discussions with colleagues
Training and workshops	Formal training	RIE, NCERT, NISHTHA FLN Training	Only 10 percentage teachers have attended formal training programs on TBP, while many have learned informally through online resources.
Implementation of TBP	Types of Toys Used	Puppets, Puzzles, Ludo,	60 percentage Teachers have used various toys like puppets and puzzles to discuss concepts such as force,

		Cardboard, Balloons	friction, geometry, human anatomy, and chemistry
Impact of TBP on Socio emotional and psychological skills	Impact on Learning	Engagement, Participation, Creativity	70 percentage teachers say that TBP is believed to improve learners' engagement and participation, fostering creativity and problem-solving skills through hands-on experiences in a joyful environment
Impact of TBP on Improving CBLO	Competency-Based Learning Outcomes	Visualisation, Understanding	65 percentage of teachers report that TBP enhances competency-based learning outcomes by helping students visualize phenomena through toys.
Impact of TBP on reducing Alternative Conceptions	Addressing Alternative Conceptions	General ACs, through experiencing concepts	70 percentage teachers say that TBP is viewed as effective in reducing alternative conceptions by providing experiential learning opportunities in the classroom
Student Satisfaction	Students' Feedback	Satisfaction, Joyfulness	45 percentage teachers have opined that Many students express satisfaction and happiness from learning through TBP, but formal integration and feedback mechanisms are needed
Challenges and Needs	Implementation Barriers	Cost, Time, Management	50 percentage of teachers are of the opinion that Challenges include the cost of materials, time constraints, proper management, and the need for a framework for concept-aligned and age-appropriate toys.
Support, Assistances	Recommendations	Regular Training, Local Toys, Toys Aligned Chapters	50 percentage teachers believe that regular training, promotion of locally available toys, and integration of chapters aligned with toys, along with initiatives like Nukkad Natak and drama should be promoted to enhance TBP awareness



Bar on Perspectives of Teachers on integration of TBP

4. Discussion

The present study may be used in numerous scenarios to help teachers, curriculum framers of state and centre, students and parents to effectively integrate toy-based pedagogy in science classrooms. The state government may arrange trainings, workshops and develop modules on locally developed and low cost or no cost toys that are culturally relevant and concept aligned. The department of education may conduct rigorous reviews and feedback programmes from the students and teachers on efficacy of toys integration in schools. The study may help identify the major challenges faced by teachers in integrating toy-based pedagogy in classrooms. The state curriculum framework for school education can inculcate the innovative pedagogy into curriculum, teaching methodologies, and assessment. More investigators may contribute to objectively identify the potential possibilities and challenges in implementing TBP effectively as a pedagogical approach.

Suggestions:

Enhanced Teacher Training: There is a need for regular, formal training programs on toy-based pedagogy (TBP) to equip educators with the knowledge and skills necessary to effectively implement TBP in their classrooms.

Resource Allocation: Schools and educational authorities should allocate funds for acquiring diverse and age-appropriate toys that align with curricular concepts, ensuring that teachers have access to the tools needed for effective TBP integration.

Curriculum Structuring: The curriculum may be restructured to inculcate toy integrated learning methods, which makes sure that educational goals are met effectively.

Peer Collaboration: It motivates teachers to find out the best practices and integrate them with TBP.

To improve the effectiveness of toy-based pedagogy in early childhood education, educational stakeholders should create a forum for student feedback, use locally made, culturally relevant resources, implement awareness campaigns, and integrate arts and drama into classroom activities. These strategies can enhance engagement and creativity, promoting a more culturally relevant and cost-effective approach to learning.

5. Conclusion

This chapter reviewed teachers' perspectives on toy-based pedagogy (TBP) in improving learning outcomes for middle-stage science and mathematics, and repositioned TBP within the broader context of artificial intelligence in education. The analysis brought out how TBP, based on experiential and play-based learning, fits very well with NEP 2020's emphasis on creativity, critical thinking, and competency-based outcomes. It can support conceptual change effectively by enabling the student to manipulate concrete objects to reconstruct understanding. In order to fit with this book's theme of transforming mathematics education in the AI era, TBP should be explicitly framed as toy-based pedagogy augmented by AI where intelligent tools extend rather than replace the core strengths of play-based learning.

AI-driven intelligent tutoring systems and adaptive learning platforms provide promising mechanisms for supporting TBP. Systematic reviews indicate that AI-based ITS can have a positive impact on K–12 learning and performance if they contain pedagogical features such as immediate feedback, guided practice, and adaptability; are in appropriate contexts/domains; and are used with appropriate pedagogy. AI-driven adaptive systems in STEM have shown 15–25% gains in academic performance plus up to 40% improvements in engagement—very strong evidence that meaningful enhancement of learning outcomes is possible through thoughtful integration.

In the context of TBP, AI can help teachers and learners in several specific ways: it can recommend toys that align with concepts; generate adaptive prompts and scaffolding during play; capture observational and assessment data

from toy-based activities; provide analytics to help teachers identify alternative conceptions, track progress, and differentiate instruction. AI-integrated smart toys are another example of how physical play objects can be enhanced with AI for cognitive as well as emotional development—this is an area where convergence between toys and AI is growing. At the same time, literature also warns about ethical, legal, and developmental concerns when AI becomes part of children's everyday learning environments; thus, underscoring responsible design as well as use.

The perspectives of teachers presented in this chapter indicate that while many see the potential for TBP to make science and mathematics more engaging and meaningful, their readiness for AI integration is uneven. Some are enthusiastic about planning lessons with AI assistance, getting adaptive feedback, using data for decisions; others have worries regarding technical infrastructure needs for training—and fear over-reliance on technology. These findings resonate with AIEd research at large highlighting challenges like inadequate technical infrastructure faculty readiness plus ethical concerns regarding data privacy algorithmic bias.

The implications for teacher education, curriculum design, and policy are straightforward. Teacher preparation programs ought to include training on AI tools that can assist toy-based and experiential learning, including how to read AI-generated analytics, how to choose and modify AI-supported toys, and how to keep a balanced, human-cantered approach where AI helps pedagogy rather than drives it. Curriculum frameworks should clearly spell out how AI and TBP can be brought together to meet competency-based learning outcomes and alternative conceptions in science and mathematics as per NEP 2020. Policy makers and school leaders need to put money into infrastructure, capacity building, and ethical guidelines so that AI-enhanced TBP is fair, open, and useful for all learners. In closing, toy-based pedagogy does not have to be thrown away or substituted in the age of AI; it can instead be changed and improved with the careful integration of AI. By placing TBP as a human-cantered approach based on play supported by smart tools driven by data, this chapter supports a vision for math and science education that is both hands-on and high-tech. The future study needs to look into long-term effects of AI-supported TBP on understanding concepts alternative conceptions; equity in middle-stage STEM classrooms; and how teacher beliefs/practices change as AI tools become more embedded in everyday pedagogy.

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