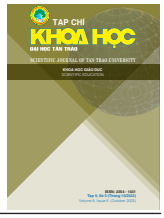
TẠP CHÍ KHOA HỌC ĐẠI HỌC TÂN TRÀO

ISSN: 2354 - 1431

http://tckh.daihoctantrao.edu.vn/



DESIGNING PLAY-BASED SCIENCE ACTIVITIES FOR PRESCHOOL CHILDREN

Hoang Thi Phuong Tham, Tran Viet Nhi, Le Nguyen Tu Uyen*

University of Education, Hue University, Vietnam

Email address: tranvietnhi@hueuni.edu.vn

https://doi.org/10.51453/2354-1431/2023/880

Article info

Received: 27/6/2023

Revised: 20/8/2023

Accepted: 04/10/2023

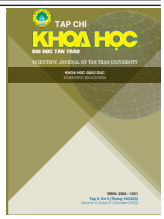
Keywords

Science exploration, science activity, play-based learning, preschool children, designing

Abstract

This study proposes principles and processes for developing play-based science activities for preschoolers, using document analysis, surveys with teachers, and educational activity design as research methods. The literature emphasizes the importance of play-based science activities in fostering children's comprehension of scientific concepts and cultivating critical thinking and problem-solving skills. Teachers play a pivotal role in guiding children, providing opportunities for exploration and discovery, and fostering a passion for learning. The survey results indicate that educators rated their competence in devising and organizing play-based science activities as inadequate, and they also need more reference materials on this subject. This article presents the principles and processes for constructing play-based science activities, along with specific examples, as reference materials for preschool teachers to improve the quality of science education for preschool children.

TẠP CHÍ KHOA HỌC ĐẠI HỌC TÂN TRÀO
ISSN: 2354 - 1431
http://tckh.daihoctantrao.edu.vn/



THIẾT KẾ HOẠT ĐỘNG KHÁM PHÁ KHOA HỌC THÔNG QUA CHƠI CHO TRẺ MẪU GIÁO

Hoàng Thị Phương Thắm, Trần Viết Nhi, Lê Nguyễn Tú Uyên*
Trường Đại học Sư phạm, Đại học Huế, Việt Nam
Địa chỉ email: tranvietnhi@hueuni.edu.vn
https://doi.org/10.51453/2354-1431/2023/880

Thông tin bài viết

Ngày nhận bài: 27/6/2023
Ngày sửa bài: 20/8/2023
Ngày duyệt đăng: 04/10/2023

Từ khóa

Thiết kế, khám phá khoa học, học tập dựa vào chơi, khám phá khoa học thông qua chơi, trẻ mẫu giáo

Tóm tắt

Nghiên cứu này được thực hiện nhằm mục đích đề xuất nguyên tắc và quy trình thiết kế hoạt động khám phá khoa học thông qua chơi cho trẻ mẫu giáo. Các phương pháp nghiên cứu được sử dụng bao gồm nghiên cứu tài liệu, khảo sát bằng bảng hỏi và thiết kế hoạt động giáo dục. Tổng quan nghiên cứu tài liệu đã chỉ ra tầm quan trọng của các hoạt động khám phá khoa học thông qua chơi trong việc thúc đẩy sự hiểu biết của trẻ em về các khái niệm khoa học và phát triển tư duy phản biện và kỹ năng giải quyết vấn đề. Giáo viên có vai trò quan trọng trong việc hướng dẫn, tạo điều kiện cho trẻ khám phá và khám phá, đồng thời thúc đẩy niềm yêu thích học tập. Khảo sát thực trạng cho thấy giáo viên tự đánh giá thấp mức độ kỹ năng lập kế hoạch tổ chức hoạt động khám phá khoa học thông qua chơi của bản thân và cho rằng tài liệu tham khảo về chủ đề này còn thiếu. Nguyên tắc, tiến trình thiết kế hoạt động khám phá khoa học thông qua chơi và ví dụ minh họa cụ thể được trình bày trong bài báo sẽ là tài liệu để giáo viên mầm non tham khảo và áp dụng nhằm nâng cao chất lượng giáo dục khoa học cho trẻ ở trường mầm non.

1. Introduction

Science education plays a crucial role in the early years of development, fostering critical thinking skills, creativity, and lifelong learning passion (National Research Council, 2012; Bodrova & Leong, 2006) [18] [3]. Through hands-on experiences and exploration, children can investigate causes and effects, make predictions, and develop an understanding of the natural world (American Academy of Pediatrics, 2016) [1]. Furthermore, early exposure to science education is associated with children's academic achievement in subsequent years, including mathematics and reading skills (Lonigan et al., 2014) [16]. Therefore, providing young children with meaningful and diverse scientific experiences from preschool age establishes a solid foundation for their learning and future success.

Learning science through play has been recognized as an effective approach in early childhood education (ECE), providing children with opportunities to develop scientific knowledge, curiosity, and an interest in science. Several studies have indicated that play-based activities can create rich contexts for children

to explore scientific concepts, engage in hands-on scientific inquiry, and develop critical thinking skills (Sarama & Clements, 2009; Bodrova & Leong, 2016; Sutterby & Lui, 2018) [28] [4] [30]. Such activities have also been found to enhance motivation, engagement, and understanding of scientific concepts among preschool children (Peplow, 2018) [24]. Furthermore, science exploration through play allows children to develop essential life skills such as problem-solving, critical thinking, and collaboration (Berk, 2020) [2]. However, designing and implementing play-based science activities pose challenges for educators. The success of these activities depends on factors including the selection of appropriate materials and activities, teacher support and guidance, as well as the alignment of activities with children's needs and abilities (Clements & Sarama, 2011) [6].

In Vietnam, the "learning through play" approach is pervasive in ECE, making the topic of play-based science activities having great interest to many researchers. Recent studies have explored the scientific foundations and analyzed the challenges faced by early childhood educators in designing STEAM games (Nhung L. B., 2022) and have proposed principles and processes for designing STEAM games for children (Nguyen et al. et al., 2021; Tran et al., 2021). With a perspective that emphasizes providing children with open and engaging opportunities to experience play and scientific practices, building scientific knowledge and skills, this study focuses on examining the current state of research on play-based science activities and identifying principles and processes for designing play-based science activities for preschool children. The findings of this study will contribute to the development of guidelines and recommendations for designing play-based science activities to promote preschool children's scientific knowledge and support their active engagement in scientific inquiry.

2. Methods

This study employs literature analysis, survey with teachers, and design educational activity. Specifically:

The research literature consists of books and scholarly articles obtained from electronic databases such as Education Research Complete, JSTOR, and Google Scholar. The keywords used for searching include "play-based science education," "early childhood science education," "preschool science education," "young children science education," and "early years science education."

The selected literature is carefully reviewed and analyzed to gain an understanding of various aspects related to play-based science education for preschool children, including concepts, objectives, the necessity, and the role of teachers. This analysis helps identify gaps in the current knowledge base and provides insights for designing educational activities.

A survey on preschool teachers' skills in designing play-based science activities was carried out among 160 preschool teachers in Hue City, Thua Thien Hue province. The survey instrument primarily consisted of a questionnaire with seven items designed on a 5- and 6-point Likert scale. The Cronbach's alpha coefficient for the entire questionnaire was 0.862, indicating sufficient reliability of the survey instrument for use. The survey data were processed using SPSS 26.0 software to calculate mean values and standard deviations.

The next step of the research focuses on developing principles and a design process for play-based science activities for preschool children. These principles, design process, and specific examples are presented based on a comprehensive review of existing literature and iterative feedback from teachers and ECE experts. These activities aim to promote children's exploration and investigation through play-based experiences, engaging with scientific concepts and processes.

3. Research results

3.1. Theoretical Framework of Play-Based Science Exploration in the Preschool

3.1.1. Concept and Characteristics of Play-based Science Exploration in the Preschool

Concept of Play-based Science Exploration

Play-based science exploration in Preschool refers to the use of play experiences and hands-on activities to introduce scientific concepts and skills to preschool children. This approach is based on the idea that children learn best through play and exploration (Sarama & Clements, 2009) [28]. Accordingly, children are encouraged to engage in exploratory and hands-on experiences that allow them to discover scientific concepts through play and investigation (Roskos & Neuman, 2013) [26]. This approach emphasizes child-

led learning, where children are given the freedom to choose their own play experiences and are provided with time and space to pursue their interests and ideas (Bodrova & Leong, 2006) [3].

Characteristics Play-based Learning

Play and play-based learning are closely related but not synonymous. Play refers to voluntary and self-directed activities of children that satisfy their play needs (Pellegrini & Bartsch, 2015) [22]. On the other hand, play-based learning is an educational approach that integrates play into the learning process to promote children's development and learning (Sarama & Clements, 2009) [28]. For example, a child may engage in a pretend play activity themed as a doctor. This playful activity will provide opportunities for the child to develop social and emotional skills, as well as imagination and creativity. In the play-based learning approach, the teacher provides materials/props for children to use (such as a doctor's kit) and encourages them to use these materials to explore scientific concepts related to health and the human body. Such activities are constructed based on children's natural inclination for play but with specific learning goals related to science education.

Play-Based Science Exploration and Scientific Inquiry

Play-based science exploration and scientific inquiry are two common approaches in ECE in general and science education in particular. Exploring science through play involves engaging children in imaginative hands-on activities to promote scientific exploration and understanding (Sarama & Clements, 2009) [28]. On the other hand, scientific inquiry emphasizes questioning and seeking answers through investigation and observation (NSTA, 2018) [19]. Both methods foster critical thinking skills and scientific knowledge in preschool children (Kirshner & Baek, 2017) [13].

The difference between these two approaches can be seen through an example related to the topic of "Plant Development" as follows:

In the play-based approach, children are provided with opportunities to participate in hands-on activities and sensory experiences related to the life cycle of plants. For instance, they can sow seeds in the soil, observe the germination of plants, take care of the growing plants, and eventually harvest them. Children can use props, toys, and images to represent different stages in the life cycle. The focus of this activity is to create a joyful and engaging environment that supports children's curiosity.

In the scientific inquiry approach, children are presented with questions and issues related to the life cycle of plants and encouraged to explore, experiment, and investigate on their own. For example, children may be asked to observe the development of different types of plants and compare them or design an experiment to test various factors influencing plant growth. The emphasis is on helping children develop critical thinking and problem-solving skills while encouraging them to seek answers on their own.

3.1.2. The Necessity of Learning Science through Play in Preschool Children

For children aged three and above, play is a predominant activity, and play-based education is an effective and appropriate method for science education not only for this age group but also for younger children. Exploring science through play during the early years is an appropriate approach that harnesses children's natural curiosity and supports their development (Isenberg & Jalongo, 2009) [10]. Pellegrini and Bohn (2005) [23] suggest that children naturally possess curiosity and a passion for exploring the world through hands-on experiences and play. This makes activities of exploring science through play highly suitable for children at this age.

Evidence from several studies demonstrates the positive impact of play-based science education during early childhood. Liang et al. (2020) [15] found that activities of exploring science through play enhance preschool children's scientific exploration outcomes, such as their ability to classify objects based on their characteristics and develop hypotheses about scientific phenomena. Another study by Bodrova and Leong (2019) [5] also revealed that play-based science activities, which combine physical and cognitive play elements, significantly enhance children's scientific knowledge compared to activities solely based on physical play. In addition to cognitive benefits, play-based science education has been shown to have social and emotional benefits for preschool children.

Furthermore, activities of exploring science through play can enhance scientific knowledge, critical thinking skills, and the motivation to explore science in

preschool children (Dewey, 1916; Pellegrini & Bartsch, 2015; Kahl et al., 2019) [7] [11] [22]. Engaging in such activities helps children develop a better understanding of scientific concepts, such as cause and effect, compared to children who do not participate (Kirshner & Baek, 2017) [13].

Moreover, play-based activities are particularly beneficial for preschool children as they provide interactive and engaging experiences for children to learn science with enthusiasm (Kirschner et al., 2017) [12]. This contributes to nurturing a love for science in preschool children and establishes a foundation for future science learning (NSTA, 2018) [19] while fostering the development of important 21st-century skills such as critical thinking, problem-solving, and collaboration (Klahr & Gillies, 2018) [14].

Exploring science through play has a positive impact on children's scientific learning outcomes and attitudes toward science (Isenberg & Jalongo, 2009) [10]. A study conducted by Raikes and Thompson (2020) [25] revealed that play-based activities centered around exploring science facilitate social interaction and collaboration among children, promoting the development of their social-emotional skills, such as effective communication with others and emotion regulation. However, it is important to note that not all play-based science activities are equally effective. Therefore, it is necessary to design engaging and developmentally appropriate activities for preschool children to maximize the benefits of play-based science education (Kirschner et al., 2017) [12].

3.1.3. The Role of Teachers in Organizing Play-Based Science Activities for Preschool Children

Recent related studies have emphasized the role of preschool teachers in designing and organizing play-based science activities for preschool children. Bodrova and Leong (2016) [4] argue that when play-based activities of exploring science are designed and supported by knowledgeable and skilled teachers, they can help children connect scientific concepts with their everyday experiences, leading to a deeper understanding of scientific concepts. The authors also highlight the importance of teacher support and guidance in promoting children's active engagement in play-based science exploration.

The study by Sarama and Clements (2009) [28] also demonstrates that play-based science activities contribute to enhancing children's motivation toward science and their attitudes toward science. The authors also note that such activities can promote the development of children's scientific knowledge and skills, including the use of scientific tools, asking scientific questions, and designing and conducting experiments. Teachers can provide meaningful scientific experiences for children and support and guide their learning while fostering children's motivation and attitudes toward science. Therefore, teachers need to receive appropriate professional training and development to effectively implement play-based science activities in preschool settings.

3.2. Current Status of Teachers' Designing Play-Based Science Activities for Preschool Children

The results of a survey of 160 preschool teachers in Hue City are presented in Table 1 below.

Table 1. Teachers' Skills in Designing Play-based Science Activities for Preschool Children

Skills	Mean	SD
1. Selecting the theme and main content of play-based activities for preschool children.	2.93	0.765
2. Determining the objectives of play-based activities for preschool children.	3.00	0.839
3. Planning for play-based science activities	3.05	0.767
4. Mobilization of materials, resources, and toys from various sources (parents, colleagues, community)	2.99	0.813
5. Establishment of a play environment (arrangement and layout of play areas, science exploration corners)	3.04	0.653

Note: Mean Score (ĐTB) = Average score; SD = Standard deviation; $1 \leq$ ĐTB ≤ 6

Table 1 shows that the average scores for each skill range from 2.93 to 3.05, indicating that these skills are generally evaluated at an average level. Among them, the skill of "Determination of objectives for play-based science activities for preschool children" has the highest average Score of 3.00, followed by the skill of "Establishment of a play environment" with an average score of 3.04. Additionally, the other skills, such as "Selection of the theme and main content of play-based science activities for preschool children," "Planning for play-based science activities," and "Mobilization of materials, resources, and toys from various sources," have relatively close average scores ranging from 2.93 to 2.99. This indicates that the evaluation of completion level for these skills is quite similar among the teachers. The standard deviations range from 0.653 to 0.839, suggesting that the score differences in the assessments by preschool teachers are not significant.

Furthermore, teachers also needed help accessing reference materials for organizing activities. Most teachers assessed the level of resource availability as "Low" (Mean Score = 1.78; Standard Deviation = 0.653). Additionally, they perceived the level of support from the school in terms of reference materials for organizing play-based science activities as below average (Mean Score = 2.74; Standard Deviation = 0.577). This indicates the need for research proposing the development of play-based science activities for preschool children.

3.3. Principles and Process of Designing Play-based Science Activities for Preschool Children

3.3.1. Principles of Designing Play-Based Science Activities

Play-based science activities need to effectively engage children in learning and discovering science (Smith & Weisz, 2017) [29]. These activities allow children to connect their experiences and scientific concepts in a fun, realistic, and age-appropriate manner (Girod & Tamir, 2012) [8] [9]. Below are five fundamental principles for designing play-based science activities for preschool children.

Principle 1 - Child-Led: Play-based activities should allow children to lead the process of exploration and investigation rather than being directed by adults (Girod & Tamir, 2012) [8] [9]. This helps stimulate children's natural curiosity and provides opportunities for them to be actively engaged in learning (Smith & Weisz, 2017) [29].

Principle 2 - Hands-on: Preschool children learn best through hands-on experiences (NRC, 2009) [17], so play-based activities should involve materials and specific manipulations that children can touch, see, and interact with (Smith & Weisz, 2017) [29].

Principle 3 - Relevance: Activities should be relevant to children's lives and provide opportunities for them to connect with their own experiences (National Research Council, 2009) [17].

Principle 4 - Collaboration: Play-based science activities should encourage children to work together, nurturing their communication and social skills (Girod & Tamir, 2012) [8] [9].

Principle 5 - Open-Ended: Activities should be structured in a way that allows room for children to explore, make predictions, and ask questions (Smith & Weisz, 2017) [29]. This allows for multiple solutions and approaches, promoting critical thinking and problem-solving skills (National Research Council, 2009) [17].

3.3.2. Process of Designing Play-based Science Activities for Preschool Children

Based on the characteristics of science activities and the features of play-based learning in preschool children, the following process can be proposed for designing play-based science activities:

Step 1 - Select a scientific concept: Choose a scientific concept that is appropriate for preschool children, such as properties of materials, plants, animals, or the senses (National Research Council, 2009) [17].

Step 2 - Gather materials: Collect materials that can be used for hands-on exploration and investigation, such as play dough, magnets, seeds, and magnifying glasses (Smith & Weisz, 2017) [29].

Step 3 - Plan the activity: Plan an activity that is child-led and has an open-ended conclusion, providing opportunities for children to observe, ask questions, and make predictions (Girod & Tamir, 2012) [8] [9].

• Introduce the concept: Introduce the scientific concept to children in a developmentally appropriate manner, using simple language and specific examples (National Research Council, 2009) [17].

• Facilitate exploration: Encourage children to explore the materials and make observations, helping them make connections with the scientific concept (Smith & Weisz, 2017) [29].

• Foster reflection: After the activity, encourage children to reflect on what they have learned and ask questions that help them relate their experiences to the scientific concept (Girod & Tamir, 2012) [8] [9].

3.3.3. Some Play-Based Science Activities for Preschool Children

Based on the principles and design process outlined above, we have developed a system of play-based science activities for preschool children. These activities have been refined based on feedback from five teachers and two experts in early childhood science education. The following four activities serve as valuable reference materials for teachers and ECE students:

Activity 1: Material Exploration

Objective: Explore the characteristics of materials through hands-on play and investigation.

Materials:

• Various types of diverse materials (e.g., paper, plastic, metal, fabric, cardboard)

• A large container of water

• A large tray

• Tweezers

• Magnifying glass

Procedure:

• Introduce the activity by informing the children that they will be exploring different materials to observe how they change when wet.

• Place the materials on the tray and allow the children to explore them through touch and the magnifying glass. Encourage them to observe and ask questions.

• Fill the large container with water and place it on the tray. Invite the children to use the tweezers to sequentially immerse each material in the water, observe what happens, and make predictions.

• After each material has been tested, ask the children what they noticed and encourage them to share their observations. Engage in a discussion about the characteristics of each material (e.g., whether it floats or sinks, is heavy or light, is soft or hard, etc.).

• Summarize the key points of the activity and ask the children what they have learned about the characteristics of different materials.

Activity 2: Color Mixing Fun

Objective:

• Understand colour mixing

• Develop observation and prediction skills

• Encourage playful and creative engagement

Materials:

• Three color containers (bowls or cups)

• Water

• Food coloring (red, blue, and yellow)

Procedure:

• Fill each container with water.

• Place a different color in each container (e.g., put yellow color in container 1, blue color in container 2, and red color in container 3).

• Allow the children to mix colors by pouring water from one container to another to observe what happens when they mix red and blue, blue and yellow, and red and yellow.

• Encourage the children to predict the resulting color after each mixing and then observe the actual outcome.

• Discuss the colors they have created and why they appear that way (e.g., red and blue create purple, blue and yellow create green, and red and yellow create orange).

Activity 3: Floating and Sinking

Objective:

• Understand the phenomenon of floating and sinking

• Develop observation and prediction skills

• Encourage playful exploration and curiosity

Materials:

• A basin or tub filled with water

• Various objects of different materials, such as wooden and plastic blocks, toy cars, plastic cups, forks, spoons, etc.

Procedure:

• Show the children the basin or tub filled with water.

• Allow the children to select objects one by one to test whether they float or sink.

• Encourage the children to make predictions about whether each object will float or sink before conducting the experiments.

• After the children have tested each object, discuss why some objects float while others sink (e.g., some objects are denser than water and sink, while others are less dense and float).

Activity 4: Exciting Bubble Fun!

Objective:

• Understand soap bubbles and how they form

• Develop observation skills

• Encourage playful exploration and creativity

Materials:

• A basin or tub filled with water

• Dish soap

• Drinking straw or wire loop for blowing bubbles

Procedure:

• Fill the basin or tub with water and add a few drops of dish soap.

• Let the children take turns blowing bubbles using the drinking straw or bubble wand.

• Encourage the children to observe the bubbles and try to identify their different shapes and sizes.

• Discuss the reasons why soap creates bubbles (soap forms a thin soap film that traps air to create bubbles).

• Encourage the children to create the largest or smallest bubble they can.

The play-based science activities mentioned above align with the principles of play-based learning for preschool children as they are child-led, hands-on, meaningful, collaborative, and open-ended. Children have the opportunity to explore and discover independently, nurturing their natural curiosity and creativity. The activities also provide opportunities for children to make connections between their experiences and scientific concepts, laying the foundation for future scientific inquiry. The discussion at the end of each activity helps reinforce children's learning and allows them to reflect on what they have discovered. These activities can be organized through outdoor play or in a science discovery corner to enhance the opportunities for hands-on science experiences for children in early childhood settings.

4. Conclusion

In conclusion, play-based science activities are crucial for the education of preschool children, providing them with engaging learning experiences and hands-on practice. The overall literature has highlighted the importance of play-based science activities in promoting children's understanding of scientific concepts and developing their critical thinking and problem-solving skills. Teachers play a vital role in guiding and facilitating children's exploration and discovery while fostering a love for learning. The results of a survey conducted with over 160 preschool teachers in the city of Hue have shown that teachers' skills in designing play-based science activities could be improved. Furthermore, teachers lack reference materials to support the design and organization of these activities in early childhood settings. The principles, design process, and specific activities presented in this article will serve as a valuable resource for teachers and students in the field of ECE. By effectively leveraging resources and support and encouraging children's participation in play-based science activities, as described above, teachers can promote children's development and lay the foundation for a lifelong love of learning.

REFERENCES

[1] American Academy of Pediatrics. (2016). The importance of play in promoting healthy child development and maintaining strong parent-child bonds. Pediatrics, 138(1), e20162591

[2] Berk, L. E. (2020). Development through the lifespan. Pearson Education, Inc;

[3] Bodrova, E., & Leong, D. J. (2006). Tools of the mind: The Vygotskian approach to early childhood education. Pearson Education.

[4] Bodrova, E., & Leong, D. J. (2016). Play as a context for the development of early scientific thinking. In S. L. Uccelli & H. F. Long (Eds.), Handbook of Research on Play in Children's Development and Learning (pp. 314-336). Routledge.

[5] Bodrova, E., & Leong, D. J. (2019). Vygotskian approach to early childhood education (3rd ed.). Routledge.

[6] Clements, D. H., & Sarama, J. (2011). Early childhood mathematics education: An analysis of the state of the research. Journal for Research in Mathematics Education, 42(4), 469-505.

[7] Dewey, J. (1916). Democracy and Education. New York: Macmillan.

[8] Girod, M., & Tamir, P. (2012). Play and development: Evolutionary, cultural, and functional perspectives. Oxford University Press.

[9] Girod, M., & Tamir, P. (2012). Play-based science learning in early childhood education: A review of the literature. Journal of Research in Childhood Education, 26(2), 199-214.

[10] Isenberg, J. P., & Jalongo, M. R. (2009). Play in early childhood education: From birth to six years. Pearson.

[11] Kahl, J., Beyer, S., & Casagrande, J. (2019). Science education in the early childhood years: An examination of teaching and learning. Journal of Science Education and Technology, 28(3), 427-439.

[12] Kirschner, S., Stegmann, K., & van Merriënboer, J. J. G. (2017). Taking the opportunity to learn science through play. International Journal of Science Education, 39(10), 1265-1286.

[13] Kirshner, B., & Baek, Y. (2017). The use of play-based approaches in science education for young children. Journal of Science Education and Technology, 26(5), 712-719.

[14] Klahr, D., & Gillies, R. M. (2018). The science of science learning: An introduction. Cambridge University Press.

[15] Liang, Y., Chen, X., & Zhang, Y. (2020). Play-based science learning in early childhood: A review of the literature. Journal of Education and Practice, 11(35), 111-119.

[16] Lonigan, C. J., Phillips, B. M., & Hooe, E. S. (2014). The development of early reading skills and the foundations of scientific knowledge. Journal of Educational Psychology, 106(4), 1134.

[17] National Research Council. (2009). Science Framework for California Public Schools: Kindergarten Through Grade Twelve. National Academies Press.

[18] National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. National Academies Press.

[19] National Science Teachers Association. (2018). NSTA Position Statement: The Importance of Play in Early Childhood Science Education.

[20] Nguyen Thi Kim Anh, Nguyen Ngoc Chau, & Nguyen Thi Thanh (2022). Game design for preschool children between 5-6 years old in Ho Chi Minh City based on the STEAM approach. Ho Chi Minh City University of Education Journal of Science, 19(6), 973-989.

[21] Nhung L B. Thiết kế và tổ chức các hoạt động trò chơi khoa học cho trẻ mẫu giáo 5-6 tuổi theo cách tiếp cận STEAM. Sci. Tech. Dev. J. - Soc. Sci. Hum.; 6(2):1527-1539.

[22] Pellegrini, A. D., & Bartsch, K. (2015). The role of play in children's development: An evolutionary perspective. In The Oxford Handbook of Evolutionary Family Psychology (pp. 381-398). Oxford University Press.

[23] Pellegrini, A. D., & Bohn, C. (2005). The role of play in children's development and learning. Handbook of child psychology, 6th ed, vol. 2: Cognition, perception, and language, 6, 761-796.

[24] Peplow, L. (2018). Play-based learning in early childhood education: Reframing the discourse. International Journal of Early Childhood, 50(1), 59-72.

[25] Raikes, H., & Thompson, R. (2020). The benefits of play-based science activities for young children. Young Children, 75(4), 44-49.

[26] Roskos, K. A., & Neuman, S. B. (2013). Play and learning in early childhood settings: From theory to practice. Pearson.

[27] Rudd, R. D., & Pryor, J. (2019). The science of learning and development in early childhood. The Future of Children, 29(1), 175-197.

[28] Sarama, J., & Clements, D. H. (2009). Early childhood mathematics education research: Learning trajectories for young children. Routledge.

[29] Smith, P. K., & Weisz, E. (2017). Play and Development: The Scientific Study of Children at Play. Cambridge University Press.

[30] Sutterby, J., & Lui, J. (2018). The role of play in young children's science learning: A review of the literature. Journal of Research in Science Teaching, 55(2), 195-219.

[31] Tran Thi Linh (2022). Designing games for preschool children towards the STEAM approach. Journal of Teaching and Learning, Issue 1, Volume 5, 2021.