European Institute of Knowledge & Innovation

Journal of Effective Teaching Methods (JETM)
ISSN: 2755-399X

Short Report

Research on kindergarten and primary school students' magnetic misconceptions and how to plan educational activities

Vasiliki Samara [1]*, Konstantinos T. Kotsis [1]

[1] Department of Primary Education, University of Ioannina, Greece
* Correspondence: samaravasiliki05@gmail.com

https://doi.org/eiki/10.59652/jetm.v2i2.124

Abstract: Because magnetism is such an abstract and complicated subject, it can be challenging for children to comprehend at times. Magnetism is a subject that youngsters find to be really exciting. The topic of magnetism is one that children find to be both fascinating and fascinating. There has not been nearly as much research done on how children perceive magnetism as there has been on other natural phenomena. This is even though youngsters consider magnetism to be something that is exciting. Despite the fact that children perceive magnetism to be more attractive than other natural phenomena, this is the case. This particular piece of research is regarded as an important piece of re-search owing to the fact that it has an impact on the way in which learning is experienced. The goal of this study is to analyze the misconceptions that are held by children who are enrolled in elementary school. The research will be conducted with the intention of providing teachers with a theoretical framework upon which they can construct educational activities that are relevant to the requirements of primary school pupils. The ability to construct educational activities that are pertinent to the requirements of elementary school kids will be made possible as a result of this innovation.

Keywords: misconceptions; magnetism; educational activities; kindergarten; primary school

Received: March 1, 2024
Accepted: Aprile 11, 2024
Published: April 16, 2024

1. Introduction

The value of students' misconceptions or alternative ideas about science concepts as teaching aids is well recognised (Kotsis, 2023). The literature contains two terms that describe children's perceptions of magnetism. During the initial phase, these are labelled as "alternative ideas," and in the subsequent phase, they are labelled as "misconceptions." The term "alternative perceptions" mainly pertains to the knowledge possessed by pupils rather than the knowledge they lack (Mevarech & Kramarsky, 1997). In contrast, "misconceptions" highlight the presence of consistently and overtly wrong knowledge systems (Leinhardt et al., 1990). Students develop misconceptions when manipulating scientific terms to fit their contradictory intuitive understandings (Vosniadou & Skopeliti, 2014). Students' ideas can impact the learning process, both during and after the learning takes place (Sukariasih, 2016). When accurate, these notions can serve as fundamental components for comprehending topics. When misunderstandings persist and are inaccurate, they can hinder effective learning (Afra et al., 2009). According to Bagno and Eylon (1997), students' misconceptions can endure and remain unchanged. Studies have demonstrated that specific difficulties persist even after receiving suitable educational intervention and continue to affect individuals throughout adulthood (Skamp, 2011). Furthermore, these issues will probably resurface several weeks after students have gained a basic comprehension of the ideas immediately following the educational intervention (Cakir, 2008). Moreover, in certain instances, pupils maintain their views and the scientific knowledge presented by the teacher due to a merging or interaction of the two perspectives. This can result in the emergence of misconceptions alongside scientifically accurate explanations of the occurrences (Driver et al., 1994). Nevertheless, rectifying children's erroneous notions, referred to as "misconceptions" in this study, is challenging without suitable educational intervention (Li, 2012). This study explicitly employs the word "misconceptions" to address students' cognitive structures. In addition, the literature has identified five mental models utilised to explain students' cognitive processes related to magnetic events (Borges & Gilbert, 1998). These mental conceptions categorise magnetism as attraction, magnetism as a cloud, magnetism as electricity, electric polarisation, and magnetism as a field. The prevailing paradigm is the model that equates magnetic with electricity (Hickey & Schibeci, 1999). Students utilise this model to decipher the phenomenon of magnetic attraction and repulsion about positive and negative charges. The magnetism model based on electric polarisation employs electrostatics to elucidate the interactions between magnets and other objects (Borges & Gilbert, 1998).

2. Bibliographic review

2.1 Children's Misconceptions about Magnetism

An examination of the study literature indicates that studies are scarce (about 25) on children's misconceptions regarding magnetism despite children's familiarity with related phenomena that are included in the curriculum of kindergarten-level physical activities. Preschool children are known to develop hypotheses about items or circumstances based on their intuition, as stated by various researchers (Gopnik, 2012; Bonawitz et al., 2019). According to Ravanis (1994), young toddlers often engage in spontaneous actions that they have not yet categorised or structured mentally. The literature study uncovers numerous non-scientific notions around magnets (Bar et al., 1997; Lemmer et al., 2018). The research examined students' ideas regarding the magnet and the material interplay. When it comes to magnetic attraction, youngsters typically exhibit two levels of reasoning (Barrow, 1987): at the first level, they make connections between diverse events, while at the second level, they assert that an unseen force enables magnets to "pull objects towards them" (Selman et al., 1982). Children under the age of 10 commonly use the terms 'forces' or 'currents' to describe the actions of pulling or pushing. They persist in deriving their explanations from mundane experiences, ascribing magnetic attraction to phenomena such as "electricity," "air pressure," or "a form of gravity" (Barrow, 1987).

Research has indicated that youngsters describe the phenomenon of magnetism as an "invisible force" (Selman et al., 1982), and they employ the term "sticking" to explain the behaviour of magnets (Piaget & Chollet, 1973). Barrow (2000) suggests that children primarily possess perceptions of magnets' appealing behaviour, and they believe that the attractive force of magnets will intensify in proportion to their size. According to Kalogiannakis et al. (2018), the children's belief in the "miraculous" capabilities of magnets and their use of inaccurate conceptual expressions indicate the importance of providing accurate and clear explanations of invisible phenomena for preschoolers to grasp science principles. The study by Bailey and colleagues (1987) examined whether primary school pupils utilise their beliefs of magnetism to anticipate the interactions between magnets. A survey was administered to 119 pupils attending primary school. The students reached two conclusions: a) the impact of a medium increases as it becomes fresher in each contact, and b) the impact of a medium increases as its size increases. Several pupils believed that a magnet's magnetic strength decreases as it ages despite this notion contradicting scientific evidence. Most individuals also concluded that a magnet half the length of the magnetic strip will have a lesser magnetic impact than a magnet twice the size. The study conducted by Smolleck and Hershberger (2011) found that youngsters between the ages of 3 and 8 held the mistaken belief that magnets attract all types of materials. In addition, they believed that magnets can attract all types of metals. The study conducted by Smolleck and Hershberger (2011) revealed that youngsters have a sense that magnets can adhere or attach objects, such as pictures or papers, to refrigerators. The youngsters occasionally demonstrated accurate anticipation of the objects in a space that exhibited magnetic attraction and those that did not exhibit magnetic attraction. The children saw that magnets exhibit various 'hues', 'forms', and 'dimensions'; they possess a 'north pole' and a 'south pole' and exert distinct 'forces'. The majority of children indicated that the magnets exhibit adhesive properties. The children held several beliefs regarding magnets, including the belief that magnets possess a mystical quality, are rigid, adhere to all types of metals, specifically adhere to silver, the strength of a magnet's magnetic field is influenced by its size, the poles of a magnet do not exert equal attraction, and a magnet is unable to attract objects that surpass its weight. Magnets cannot attract items with greater hardness, thickness, strength, or size than the magnet. Research has found that children below seven struggle to differentiate between objects/materials that are magnetically attracted and those that are not. In other words, they cannot explain magnetic attraction (Finley, 1986; Ravanis, 1994).

The literature also highlights students' errors regarding their comprehension of the magnetic force generated by magnets. The belief that larger magnets possess greater strength than smaller magnets is a widely held misperception among students at all academic levels

(Tanel & Erol, 2005; Smolleck & Hershberger, 2011; Lemmer et al., 2018). The belief that "direct contact between a magnet and a material is necessary for attraction to occur" was seen in a group of pupils ranging from 9 to 18 years old (Bar et al., 1997). Research has also uncovered misunderstandings among students at various educational levels regarding the range at which magnets may draw materials (Bar et al., 1997; Bar & Zinn, 1998; Hickey & Schibeci, 1999). Meyer (1991) conducted research to examine the preexisting ideas of primary school children regarding the strength of different magnets. The children responded that the size of a magnet directly correlates with its strength, allowing it to attract objects from a larger distance. Children specifically stated that the largest magnet possesses the greatest magnetic field, can attract, move, or lift the largest quantity of magnetic objects, can attract more objects through a non-magnetic field, can hold a greater number of magnetic objects in a chain, can attract magnetic objects from a weaker magnet, and exhibits the highest measurable attraction.

2.2 Planning of Educational Activities

By incorporating well-designed activities and utilising diverse instructional methods, it is possible to assist young children in correcting their misconceptions about magnetism (Samara & Kotsis, 2023). A study by Christidou et al. (2009) examined the efficacy of three distinct teaching methods for introducing the concept of magnetic attraction to preschool-aged children. The initial method focused on children's alternate perspectives on magnets and magnetic forces, as well as their interactions with one another in the classroom. The second method prioritised children's views and incorporated tailored activities utilising instructional resources such as storytelling, experimentation, and dramatisation. The third approach solely focused on the teacher and their control over magnetic attraction. The findings of this study indicated that youngsters who engaged in the initial two methodologies demonstrated a superior comprehension of magnetic attraction. Conversely, the third technique failed to alter their misconceptions.

A separate study (Kalogiannakis et al., 2018) investigated the instruction of magnetism in kindergarten using a different method, where children were exposed to illustrated stories relating to the topic before the teaching intervention. The findings revealed that the children had a limited understanding of magnets and their characteristics. Furthermore, they had misconceptions about the definition of magnets, utility, material composition, and origin. They were unaware of the magnet's power to repel, merely its ability to attract. The children hypothesised that the magnets could attract due to adhesive on their surfaces, a substance commonly utilised by individuals of their developmental stage. Identifying the specific components responsible for magnetic attraction had not been resolved. Nevertheless, it was comprehended that magnets can attract objects other than magnets themselves. Following the instructional intervention, the children could formulate a suitable definition of magnets. Furthermore, they were able to accurately discern the composition of the substance by the use of magnets. They comprehended that a magnet possesses the characteristics of attraction and repulsion and that this intangible force is accountable for these attributes. In addition, most children comprehended the magnet's ability to attract iron objects solely. However, it failed to recognise its source and usefulness sufficiently before and during the instructional intervention. Dimitriou (2015) re-searched the development of object-sorting skills based on their interaction with magnets and the cultivation of sequencing skills based on magnet strength. The study involved implementing specific activities designed with a didactic learning sequence. Following the instruction, it was noted that the youngsters could categorise the objects based on their magnetic attraction and arrange them according to their strength.

The categorisation of objects according to their magnetic attraction property is inconsistent with the findings of Temertzidou et al. (2014), wherein no kid successfully classified materials into magnetic and non-magnetic categories without error, even after evaluation. Before receiving education, youngsters could not identify any magnetic objects or could only identify one. Only two of the 32 children could correctly identify two or three objects attracted to the magnet. However, these two children made simultaneous inaccurate identifications, such as "nail, paper clip, coin, and glass decoration" or "coin, paper clip, and plastic cup". Before instruction, 18 of the 32 children involved in the study successfully arranged the magnets in the correct sequence, demonstrating their ability to identify the huge magnet as the strongest, followed by the medium and small magnets, respectively (Dimitriou, 2015). Ravanis (1994) advocated engaging children in play and manipulation with magnets to uncover the reciprocal forces of connection. Studies have demonstrated that employing an alternative teaching approach that involves active and experiential participation of children throughout the educational process might facilitate their comprehension of the idea of magnetism (Rendom et al., 2022). According to a different study conducted by Constantinou et al. in 2013, the performance of two groups of children aged 4-6 on two different definitions of the magnet was influenced more by their actual age rather than their cognitive development when they were exposed to a structured instructional intervention. Nevertheless, research has demonstrated that students' misconceptions persist even after implementing educational interventions. In his study, Barrow (1987) examined the perceptions of magnets among seventy-eight pupils spanning various age groups. The investigation into children's prior perceptions determined that the youngsters had a sufficient understanding of magnet usage. For instance, they knew that magnets adhere to refrigerators and attract metal pins based on their everyday experiences. Nevertheless, a few students comprehended pole attraction and repulsion principles despite the pedagogical intervention. Additionally, they held the misconception that the poles just existed at the extremities of the magnet (Barrow, 1987).

3. Conclusions

A methodical approach is essential for developing a structured analysis framework to compare communication techniques and their impact on developing kindergarten activities related to magnets and magnetic attraction. When examining the findings of the literature above research on primary school children's misunderstandings regarding the concept of Magnetism, it is imperative for every educator to take into account the following factors before designing relevant activities:

1. Children struggle to articulate the notion of magnetism, sometimes relying on their everyday experiences and mistakenly attributing magnetic attraction to phenomena such as "electricity," "air pressure," or "a form of gravity".
2. Children are unaware of the capability of magnets to repel; they are merely able to attract.
3. Children believe that magnets can attract all types of metals. They include in their responses the materials that magnets can attract and those that do not exhibit any attraction towards magnets.
4. Children may struggle to comprehend that two other magnets are produced when a magnet is bisected, each possessing a positive and a negative pole.
5. Children believe that the impact of a medium (such as a magnet) is higher when it is more unique or different from what they are used to.
6. Children tend to view giant magnets as more potent than smaller ones.
7. Children believe that the proximity of the magnet to an object will impact its magnetic attraction. This belief is shared by children between the ages of 9 and 18, who have voiced that "the magnet needs to touch a material to attract it physically".

Funding: This research received no external funding.

Institutional Review Board Statement: The study did not require ethical or other kinds of approval.

Conflicts of Interest: The authors declare no conflict of interest.

References

Afra, N. C., Osta, I., & Zoubeir, W. (2009). Students' alternative concepts about electricity and the effect of inquiry-based teaching strategies. *International Journal of Science and Mathematics Education, 7*(1), 103-132. https://doi.org/10.1007/s10763-007-9106-7

Bagno, E., & Eylon, B.S. (1997). From problem solving to a knowledge structure: An example from the domain of electromagnetism. *Journal of Physics, 65*, 726–736. http://dx.doi.org/10.1119/1.18642

Bailey, J., Francis, R.G., & Hill, D.M. (1987). Exploring ideas about magnets. *Research in Science Education, 17*, 113–116. https://doi.org/10.1007/BF02357178

Bar, V., & Zinn B. (1998). Similar frameworks of action-at-a-distance: Early scientists' and pupils' ideas. *Science and Education, 7*, 471-498. https://doi.org/10.1023/A:1008687204309

Bar. V., Zinn B., & Rubin, E. (1997). Children's ideas about action at a distance. *International Journal of Science Education, 19*(10), 1137-1157. https://doi.org/10.1080/0950069970191003

Barrow, L. H. (1987). Magnet Concepts and Elementary Students' Misconceptions. In J. Novak (Ed.), *Proceedings of the Second International Seminar on Misconceptions and Educational Strategies in Science and Mathematics* (pp. 17-22). Ithaca, NY: Cornell University Press.

Barrow, L. H. (2000). Do elementary science methods textbooks facilitate the understanding of magnet concepts? *Journal of Science Education and Technology, 9*(3), 199–205. https://doi.org/10.1023/A:1009487432316

Bonawitz, E., Ullman, T. D., Bridgers, S., Gopnik, A., & Tenenbaum, J. B. (2019). Sticking to the Evidence? A Behavioral and Computational Case Study of Micro-Theory Change in the Domain of Magnetism. *Cognitive science, 43*(8), 1-29. https://doi.org/10.1111/cogs.12765

Borges, A. T., & Gilbert, J. K. (1998). Models of magnetism. *International Journal of Science Education, 20*(3), 361–387. https://doi.org/10.1080/0950069980200308

Cakir, M. (2008). Constructivist approaches to learning in science and their implications for science pedagogy: A literature review. *International Journal of Environmental & Science Education, 3*(4), 193–206. https://files.eric.ed.gov/fulltext/EJ894860.pdf

Christidou, V., Kazela, K., Kakana, D., & Valakosta, M. (2009). Teaching magnetic attraction to preschool children: A comparison of different approaches. *International Journal of Learning, 16*, 115-128. https://doi.org/10.18848/1447-9494/CGP/v16i02/46130

Constantinou, C., Raftopoulos, A., Spanoudes, G., & Natsopoulos, D. (2013). Pre-schoolers construction of operational definitions in magnetism. *The Journal of Emergent Science, 5*, 6–21. https://www.researchgate.net/publication/237063119_Preschooler%27_Construction_of_Operational_Definitions_in_Magnetism

Dimitriou, D. (2015). Cultivating science skills in kindergarten by teaching magnets and their properties (Master thesis). https://dspace.uowm.gr/xmlui/handle/123456789/200

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science.* London: Routledge. https://doi.org/10.4324/9781315747415

Finley, F. N. (1986). Evaluating Instruction: The complementary use of clinical interviews. *Journal of Research in Science Teaching, 23*(7), 635–650. https://doi.org/10.1002/tea.3660230706

Gopnik, A. (2012). Scientific Thinking in Young Children: Theoretical Advances, Empirical Research and Policy Implications. *Science, 337*(6102), 1623–1627. http://dx.doi.org/10.1126/science.1223416

Hickey, R. & Schibeci, R. A. (1999). The attraction of magnetism. *Physics Education, 34*(6), 383–388. https://doi.org/10.1088/0031-9120/34/6/408

Kalogiannakis, M., Nirgianaki, G. M., & Papadakis, S. (2018). Teaching Magnetism to Preschool Children: The Effectiveness of Picture Story Reading. *Early Childhood Education Journal, 46*, 535–546. https://doi.org/10.1007/s10643-017-0884-4

Kotsis, K. T. (2023). Alternative ideas about concepts of physics, a timelessly valuable tool for physics education. *Eurasian Journal of Science and Environmental Education, 3*(2), 83-97. https://doi.org/10.30935/ejsee/13776

Leinhardt, G., Zaslavsky, O., & Stein, M. K. (1990). Functions, graphs and graphing: tasks, learning and teaching. *Review of Educational Research, 60*(1), 1–64. https://doi.org/10.3102/00346543060001001

Lemmer, M., Kriek, J. & Erasmus, B., (2019). Analysis of Students' Conceptions of Basic Magnetism from a Complex Systems Perspective. *Research in Science Education, 50*, 375–392. https://doi.org/10.1007/s11165-018-9693-z

Li, J. (2012). Improving students' understanding of electricity and magnetism. Doctoral Dissertation. University of Pittsburgh. (Unpublished). https://d-scholarship.pitt.edu/11767/1/Jing_Li%27s_Doctoral_Thesis_4_a%26s_format_revised7.pdf

Mevarech, Z. R., & Kramarsky, B. (1997). From verbal descriptions to graphic representations: stability and change in students' alternative conceptions. *Educational Studies in Mathematics, 32*, 229–263. https://doi.org/10.1023/A:1002965907987

Meyer, K. (1991). Children as experimenters: elementary students' actions in an experimental context with magnets (Doctoral dissertation). University of British Columbia. https://open.library.ubc.ca/cIRcle/collections/ubctheses/831/items/1.0055294

Piaget, J., & Chollet, M. (1973). Le problème de l'attraction à propos des aimants. In J. Piaget (ed.), *La formation de la notion de force* (pp. 223-243). Paris: PUF, Paris.

Poimenidou, M., & Christidou, V. (2010). Communication practices and the construction of meaning: science activities in the kindergaden. *Creative Education, 1*(2), 81–92. http://dx.doi.org/10.4236/ce.2010.12013

Ravanis, K. (1994). The discovery of elementary magnetic properties in Preschool age. Qualitative and quantitative research within a Piagetian framework. *European Early Childhood Education Research Journal, 2*(2), 79–91. http://dx.doi.org/10.1080/13502939485207621

Rendon, J. D. L., Doloretos, N. L., Capilitan, L. B., Dumaan, D. L., Mamada, M. J. D., & Mercado, J. C. (2022). Alternative Teaching Methods in Electricity and Magnetism. International Journal of Multidisciplinary: *Applied Business and Education Research, 3*(8), 1600-1606. https://doi.org/10.11594/ijmaber.03.08.23

Samara, V., & Kotsis, T. K. (2023). The use of new technologies and robotics (STEM) in the teaching of sciences in primary education: the concept of magnetism: A bibliographic review. *European Journal of Education Studies, 10*(2). http://dx.doi.org/10.46827/ejes.v10i2.4652

Selman, R. L., Krupa, M. P., Stone, C. R., & Jacquette, D. S. (1982). Concrete Operational Thought and the Emergence of the Concept of Unseen Force in Children's Theories of Electromagnetism and Gravity. *Science Education, 66*, 181-194. https://doi.org/10.1002/sce.3730660205

Skamp, K. (2011). *Teaching primary science constructively.* Cengage Learning.

Smolleck, L., & Hershberger, V. (2011). Playing with science: An investigation of young children's science conceptions and misconceptions. *Current Issues in Education, 14*(1), 1-32. https://cie.asu.edu/ojs/index.php/cieatasu/article/view/324/120

Sukariasih, L. (2016). The use of cognitive conflict strategy to reduce student misconceptions on the subject matter of rectilinear motion. *International Journal of Education and Research, 4*(6), 483 492. https://www.ijern.com/journal/2016/July-2016/38.pdf

Tanel, Z., & Erol, M. (2005). Lisans düzeyindeki öğrencilerin manyetik alan şiddeti, manyetik akı yoğunluğu ve manyetizasyon kavramlarına yönelik yanılgıları [Misconceptions of undergraduate students on the magnitude of magnetic field, magnetic flux density and magnetisation]. Türk Fizik Derneği 23. https://scholar.google.com/citations?view_op=view_citation&hl=el&user=5MaOOIMAAAAJ&citation_for_view=5MaOOIMAAAAJ:kh2fBNsKQNwC

Temertzidou, E., Papadopoulou, P., & Kariotoglou, P. (2014). A study of preschool children's skills in classifying materials based on their magnetic properties (Greek). In *Natural Sciences and Environment in Preschool Education Searches and Suggestions.* Gutenberg. https://www.researchgate.net/publication/280801641_Melete_ton_dexioteton_paidion_proscholikes_elikias_sten_taxinomese_ylikon_me_base_tis_magnetikes_tous_idiotetes#fullTextFileContent

Vosniadou, S., & Skopeliti, I. (2014). Conceptual change from the framework theory side of the fence. *Science and Education, 23*, 1427–1445. http://dx.doi.org/10.1007/s11191-013-9640-3