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9–10-YEAR-OLD STUDENTS' IDEAS ABOUT LIGHT AS AN ENTITY: TEACHING PERSPECTIVES

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Abstract:
The child, even when very young, has ideas about physical concepts and phenomena, and these ideas play a role in the learning experience. For the physicist, light is an entity that propagates in space from a source that interacts with objects it encounters in its path and then produces various perceptible effects. Data from relevant research shows that 4 to 12-year-old children have ideas that do not correspond to the school scientific models. In this research, we study the ideas of 9-to 10-year-old children about the concept of light. 134 primary school children (69 female and 65 male) participated in this study. The directive individual interview was the technique we used in our research. Results show that 9-10 years old children used different categories of light ideas.

Keywords: children's ideas, light, Science Education

1. Introduction

In the context of Science Education, the question of the construction of ideas of the physical world in the child's mind constitutes a sufficiently explored field of research. A large part of contemporary research focuses on the study of spontaneous ideas of students of different ages for various concepts and phenomena (Kontili et al., 2025; Nertivich, 2013; Ravanis, 2013; Rodriguez et al., 2014; Tin, 2022). In the last decades, in several studies we can see that, from birth, children approach the physical world, formulate and reformulate certain ideas, solve problems and gradually acquire knowledge of physical phenomena. Starting from the hypothesis that everyone in each situation mobilizes personal explanatory systems, it is often found that their own idea can be an obstacle to the appropriation of scientific concepts (Arun, 2023; Ravanis, 2020, 2021; Sotirova, 2024; Tin, 2016).

Students' ideas, being the product of the child's individual and social history, are in continuous interaction with the socio-cultural and educational environment and

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therefore, have a dynamic, developmental and evolutionary character. Thus, if the ideas that the child uses to approach the phenomena of the natural world are distant or in contradiction with certain elements of scientific models, the dominant ideas of current research in Science Education field, aim at the construction of pedagogical interventions and didactic situations likely to promote the transition to conceptions and mental forms explanatory of naive, implicit, local and unconscious ideas of notions or phenomena (Baldy, 2023; Charalampopoulou et al., 2023; Fragkiadaki et al., 2016; Rodriguez, 2018; Sotirova 2017, 2020).

As has often been demonstrated by descriptive research focused on the ideas of light and various optical phenomena that children aged 4 to 12 have, among a series of difficulties regarding the propagation and interaction of this physical entity with different objects, the main obstacle concerns the recognition of light as a particular-autonomous entity, produced in light sources and causing phenomena as it propagates through space. According to the authors who have studied this subject, this difficulty stems from the tendency of subjects to associate light exclusively with its source or the visible effects it causes (Castro, 2013, 2019; Grigorovitch, 2014; Guesne, 1984, 1985; Ravanis et al., 2002; Rodriguez & Castro, 2020). This kind of reasoning, apart from the approach to light itself, results in difficulties and obstacles in understanding phenomena that are approached by Geometric Optics, such as, for example, the formation of shadows, reflection, refraction, lenses, vision (Castro, 2018; Grigorovitch, 2015, 2020; Esgalhado et al., 1987; Fawaz, 1985; Keles et al., 2010; Kokologiannaki et al., 2013; Kottara et al., 2024; Ravanis et al., 2005, 2010; Voutsinos, 2013; Yurumezoglu, 2009).

The research presented in this article is based on an approach that aims to capture children's ideas about light in order to identify their difficulties that should be taken into account in the following educational and teaching process. Several psychological and epistemological theories clearly show that systematic guidance can transform children's reasoning and cognitive patterns. The proper didactic question that arises then is to know how the teacher can contribute, through guidance, to the access by children to new explanatory models; in other words, how the teacher, knowing in detail the spectrum of possible obstacles, can help the student to reorganize and modify his spontaneous ideas of the physical world (Arun, 2019; Draganoudi et al., 2023; Hoang, 2019; Mabejane et al., 2018; Petrovici, 2008).

Our research focuses on the study and categorization of ideas of 9-10-year-old children on the concept of light and the examination of possible differences between the ideas of boys and girls. From the results obtained, we attempt to develop and schematize the main axes of a model of didactic intervention aimed at overcoming the cognitive obstacles created by the students' own ideas.

2. Methodology

This research involved 134 subjects (65 boys, 69 girls) aged 9-10 years old, with an average age of 9.41. The participants came from 9 primary school classes, and the sample selection was convenient (Cohen et al., 2018; Fraenkel et al., 2019). The children in this sample had no prior organized educational intervention at school on the concept of light or other optical phenomena. Their academic performance was average, and their parents had no education or scientific expertise in science or technology.

The identification of children's ideas was carried out through individual semi-structured interviews, which took place in the schools' laboratories, with the permission of the school, the written consent of the parents and the voluntary participation of the students. Each interview lasted approximately 15 minutes and was carried out by a researcher who was not a teacher in any of these classes (Creswell et al., 2018).

Five tasks were proposed to each student. The questions asked concerned the recognition of light as a distinct entity in space. The interview took place in a room lit by sunlight and lamps and specially arranged for this purpose inside the school. Next, we will present the tasks, the devices and some characteristic excerpts of children's responses. We also present the frequencies of the subjects' responses, and we propose a categorization of the children's ideas. For the comparison of possible differences between the ideas of boys and girls, the X^2 test was carried out.

3. Results

To gather various types of information about children's ideas of light, different types of tasks were used:

a) "Open-ended question tasks" (1 and 2): These allow us to identify the aspects that children can verbally express when asked about light.
b) "Experimental situation tasks" (3, 4, and 5): These are presented as open-ended problems and provide information not strictly related to children's verbal expression.

Task 1

Each child was asked the question: "What light is to you?". With this question, we seek to know if children spontaneously distinguish light as an entity separate from light sources and visible effects. From this first question, we obtained answers that we classified into four categories:

a) Responses that recognize the existence of light as an entity in space. For example, "It is like….. train tracks coming from the sun", "......they are the rays that cross the room....", ".....are rays that can and do pass through the windows …..".
b) Responses centered on the visible effects produced by light. For example, ".....is that white thing on the desk, the chair, the wall.....", "Light .... illuminates the room and objects".
c) Responses centered on light sources. For example, "It's a lamp that lights us....", "It's the lamps… and another kind.... the sun".
d) No response or responses in which the formulation of ideas is not clear.

Task 2

Each child was asked the question: "What does light do?". With this question, we want to know if children focus on light sources, their operating characteristics, and some directly perceptible phenomena such as heating and lighting, or if they recognize other more general phenomena such as life, plant growth, etc. The answers obtained from this question were classified into four categories:

a) Responses that recognize more general effects caused by light as an entity. For example, ".... (light) illuminates the whole planet", "....it makes day".
b) Responses centered on the perceptible effects produced by light. For example, "It illuminates the blackboard and the table", "We see the light of the sun in different things....".
c) Responses centered on the presence and function of light sources. For example, ".... it is we who turn it on (the lamp) and it lights the room ....", "Light is in in the lights and…. in the sun….. that illuminates us".
d) No response or responses in which the formulation of ideas is not clear.

Table 1 presents the distribution of subjects' responses to the two open-ended question tasks proposed.

Table 1: Frequencies of boys' and girls' responses to the two open-ended question tasks

	Task 1		Task 2	
	Boys	Girls	Boys	Girls
General effects	5	7	8	9
Perceptible effects	12	14	41	39
Light sources	37	35	16	21
No response	11	13		

Task 3

We ask the children to show us some places in the room, "where there is light?". When the children exclusively show us the functioning light sources and/or the well-lit or strongly lit surfaces, we ask them to show us other places to check if they can evoke light in space. The children's responses were categorized as follows:

a) Recognition of light as an autonomous entity in space or on weakly lit surfaces. For example, "Light is everywhere all-around and... fills the air...", "It's below…. above, to the left and to the right... everywhere", "...it's everywhere.... everywhere you look it's light….".
b) Focus on strongly lit surfaces and/or light sources. For example, "I see light on the curtains, on the table, and there on the floor...", "It's in the lamp... and in places where we can see it...", "It's everywhere... on the floor... on the table... (There, on the ceiling?)… no... I don't see light there", "It's the sun and electric lamps in the room", "When we turn on this electric lamp... it has light (touches the lamp) ... it's not on... it's hiding its light now...".
c) No response or responses where the formulation of ideas is unclear.

Task 4

By turning on a flashlight, we produce a light spot on the wall, and we ask each child: "Where is there light coming from the flashlight?". If the children recognize the existence of light in the flashlight and on the wall, we ask them, pointing somewhere between the flashlight and the wall: "Is there light between the flashlight and the wall?". This situation gives children the opportunity to recognize light outside of sources, on a light spot or in space, within a familiar situation. The answers obtained were classified into four categories:

a) Recognition of light in space. For example, "It is everywhere in the air .... up to the wall ...... we cannot always see it".
b) Focus on the light spot on the wall and/or on light sources. For example, "There is on the white wall ... here it is ... the illuminated round spot ....", "There .... on the wall", "The light is in the bulb and on the wall', 'It's the flashlight that you are holding".

Task 5

Place two rectangular pieces of cardboard vertically on a horizontal table, so that the pieces of cardboard are a few centimeters apart. A short distance away, we place a light source (figure 1). The piece of cardboard opposite the lamp has a hole in it at the same height as the lamp. When the lamp is on, the beam formed between the two cardboard boxes is not visible due to the diffuse lighting of the room. So, children will be asked to think about an entity that is not perceived.

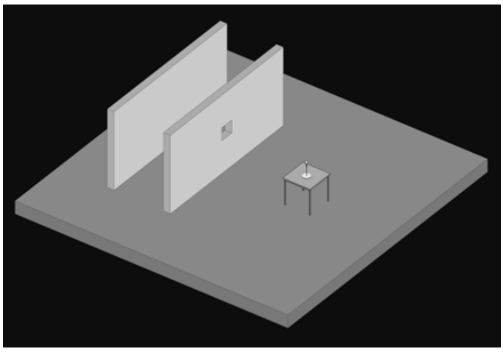

Figure 1: The experimental setup

We turn on the lamp and ask the children if there is light in the space between the two vertical pieces of cardboard. With this task, we seek to know if the children recognize light as an entity in space, this time within the context of an unfamiliar situation. The children's responses were classified into two categories:

a) Light is recognized in the space before and between the two pieces of cardboard. For example, ".... it goes to the hole .... it passes through there, it continues between the two pieces of cardboard .... and it arrives at the cardboard", "…. it passes through the hole and it is located there (between the two pieces of cardboard)".

b) Light is not recognized in space. For example, "The lamp .... it illuminates the cardboard… (And the light?) …. The light…. is on the cardboard ….", "On the cardboard .... there is light".

Table 2 shows the distribution of the subjects' responses to the three experimental task-situations proposed.

Table 2: Frequencies of boys' and girls' responses to the three experimental tasks

	Task 3		**Task 4**		**Task 5**	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Space	12	13	18	21	16	19
Surfaces/sources	52	56	47	46	49	50
No response	1			2		

4. Discussion, Pedagogical Implications and Conclusions

From an analysis of the responses, we can observe the difficulties of 9-10-year-old children and formulate categories of ideas of the subjects on the concept of light. The results obtained from the first two open-ended question tasks indicate that, for the majority of children, light is associated with light sources. This corresponds to a common social interpretation centered on perceptual aspects. The focus on light sources and/or on the effects produced constitutes an obstacle to a conception of light as an entity in the space between a source and a reflecting surface. The results obtained from the three experimental situation tasks confirm the results obtained from the first two open-ended question tasks. It is obvious that children firmly associate light with light sources. They also associate it with the strong light imprints on the various everyday objects in their space, as in the case where we used a flashlight. These data are consistent with the results of the relevant literature (Castro, 2013; Grigorovitch, 2014; Rodriguez & Castro, 2020).

Regarding the ideas of boys and girls, no distinctions could be observed between the two samples, given that the X^2 test does not give any statistically significant differences. The problems and difficulties found are common to both groups of children.

From a didactic and pedagogical point of view, these results lead us to consider that the essential obstacle at the age of 9-10 is not simply that of recognizing the existence of light in space. The essential obstacle relates to the difficulty of considering that light and light sources are entities that do not have the same status. This difficulty obviously has implications at the didactic level, given that the change of primitive conceptions of the student cannot occur spontaneously. Nevertheless, the clear knowledge of the different types of ideas allows the construction of didactic procedures likely to favor the transition to new ideas, compatible with the school scientific model of Geometric Optics (Castro et al., 2014; Rodriguez et al., 2016).

If light is attached strictly to light sources, it is impossible to understand any problem relating to phenomena involving the rectilinear propagation of light in all directions, such as, for example, the formation of shadows, diffusion phenomena, the formation of images by mirrors or lenses. Therefore, the recognition of light as an entity distinct from the source is a prerequisite for any didactic activity relating to teaching on the concept of light.

This research was carried out as part of the development of the main axes of a didactic model for the cognitive construction of the concept of light. We hope to have given some indications that the planning of activities on light for children of 9-10 years of age should mainly aim at overcoming the obstacle concerning the assimilation of light to its source. The data of this research are of interest for the formulation of teaching practices and for the development of teaching and teacher training programmes (Arun, 2017, 2018; France, 2008; Hoang, 2019; National Research Council, 2011, 2012). Indeed, the particular significance of the important obstacle that children encounter in understanding light affects the set of possible teaching objectives in the context of Geometric Optics and therefore, measures need to be taken across the whole spectrum of the preparation and implementation of teaching.

Declaration of Conflict of Interest

The author declares no conflict of interest.

About the Author

Charilaos Voutsinos obtained her Master's degree in Education Sciences from the Université de Provence in France and teaches in primary education in Canada.

Références

Arun, Z. (2017). Formation des enseignants et recherche en didactique des sciences. *European Journal of Education Studies*, *3*(9), 206-216. https://doi.org/10.5281/zenodo.852542

Arun, Z. (2018). Questions sur la formation initiale des enseignants en didactique des sciences : Une vision alternative. *European Journal of Alternative Education Studies*, *3*(1), 44-53. https://doi.org/10.5281/zenodo.1185434

Arun, Z. (2019). Le passage des sciences physiques et naturelles à leur didactique : réflexions sur un cadre pour la formation des enseignants. *European Journal of Education Studies*, *6*(2), 50-60. https://doi.org/10.5281/zenodo.2669525

Arun, Z. (2023). Difficultés liées à l'enseignement des sciences physiques en laboratoire : points de vue des enseignants. *European Journal of Education Studies, 10*(7), 1-12. http://dx.doi.org/10.46827/ejes.v10i7.4852

Baldy, E. (2023). Children's representation of the Earth at the end of elementary school: the role of spherical and geographical information carried by the globe. *Review of Science, Mathematics and ICT Education*, *17*(2), 5-25. https://doi.org/10.26220/rev.4479

Castro, D. (2013). Light mental representations of 11-12 year old students. *Journal of Social Science Research*, *2*(1), 35-39. http://dx.doi.org/10.24297/jssr.v1i1.3055

Castro, D. (2018). L'apprentissage de la propagation rectiligne de la lumière par les élèves de 10-11 ans. La comparaison de deux modèles d'enseignement. *European Journal of Education Studies*, *4*(5), 1-10. http://dx.doi.org/10.5281/zenodo.1220417

Castro, D. (2019). Approches didactiques à l'école maternelle : la numérique et la traditionnelle au cas de la lumière. *European Journal of Open Education and E-learning Studies*, *4*(1), 113-123. https://doi.org/10.5281/zenodo.3475551

Castro, D., & Rodriguez, J. (2014). 8–9-year-old pupils' mental representations of light: teaching perspectives. *Journal of Advances in Natural Sciences*, *2*(1), 40-44. http://dx.doi.org/10.24297/jns.v2i1.5030

Charalampopoulou, P., Kaliampos, G., & Ravanis, K. (2023). The construction of precursor models in the thinking of young children: the case of expansion and contraction of metals. *Education Sciences, 13*(12), 1198. https://doi.org/10.3390/educsci13121198

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge. Retrieved from https://www.routledge.com/Research-Methods-in-Education/Cohen-Manion-Morrison/p/book/9781138209866

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications. Retrieved from https://us.sagepub.com/en-us/nam/research-design/book258713

Draganoudi, A., Lavidas, K., Kaliampos, G., & Ravanis, K. (2023). Developing a research instrument to record preschool teachers' beliefs about teaching practices in natural sciences. *South African Journal of Education, 43*(1), 2031. https://doi.org/10.15700/saje.v43n1a2031

Esgalhado, A., & Rebordao, J. (1987). À propos de modèles spontanées de phénomènes liés à la lumière. In A. Giordan & J.-L. Martinand (Eds), *Actes des IXèmes Journées Internationales sur l'Éducation Scientifique* (pp. 303-308). Chamonix.

Fawaz, A.-A. (1985). *Image Optique et Vision. Étude exploratoire sur les difficultés des élèves de première au Liban*. Thèse de troisième cycle, Université Paris 7, Paris, France. Retrieved from https://theses.hal.science/tel-01273002v1

Fragkiadaki, G., & Ravanis, K. (2016). Genetic research methodology meets Early Childhood Science Education Research: a Cultural-Historical study of child's scientific thinking development. *Cultural-Historical Psychology*, *12*(3), 310-330. https://doi.org/10.17759/chp.2016120319

Franse, R. (2008). *Science is Primary. Onderzoeken en ontwerpen in groep 1 en 2*. Nationaal Centrum voor Wetenschap en Technologie: Hands-on, Brains-on. Te verkrijgen via R. F ranse, science center NEMO.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2019). *How to design and evaluate research in education* (10th ed.). McGraw-Hill Education. Retrieved from https://www.mheducation.com/highered/product/how-design-evaluate-research-education-fraenkel-wallen/M9781260016103.html

Grigorovitch, A. (2014). Children's misconceptions and conceptual change in Physics Education: the concept of light. *Journal of Advances in Natural Sciences*, *1*(1), 34-39. http://dx.doi.org/10.24297/jns.v1i1.5037

Grigorovitch, A. (2015). La formation des ombres : représentations mentales des élèves de 7-9 ans. *Educational Journal of the University of Patras UNESCO Chair*, *2*(2), 102-109.

Grigorovitch, A. (2020). L'enseignement des phénomènes optiques dans un cadre de démarche d'investigation. *European Journal of Education Studies*, *7*(6), 147-156. http://dx.doi.org/10.5281/zenodo.3749379

Guesne, E. (1984). Children's ideas about light. In UNESCO (Ed.), *New Trends in Physics Teaching* (pp. 179-192). Paris: UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000136815

Guesne, E. (1985). Light. In R. Driver, E. Guesne, A. Tiberghien (eds), *Children's Ideas in Science* (pp. 10-32). Philadelphia: Open University Press. Retrieved from https://archive.org/details/childrensideasin0000unse

Hoang, V. (2019). L'enseignement de la physique à partir des représentations : un projet collaboratif. *European Journal of Education Studies*, *6*(9), 306-315. http://dx.doi.org/10.5281/zenodo.3595417

Keles, E., & Demirel, P. (2010). A study towards correcting student misconceptions related to the color issue in light unit with POE technique. *Procedia Social and Behavioral Sciences*, *2*, 3134-3139. https://doi.org/10.1016/j.sbspro.2010.03.477

Kokologiannaki, V., & Ravanis, K. (2013). Greek sixth graders mental representations of the mechanism of vision. *New Educational Review*, *33*(3), 167-184. https://doi.org/10.15804/tner.13.33.3.14

Kontili, E.-M., Kaliampos, G., & Ravanis, K. (2025). The effect of human presence on the representations of children 4-6 years old in the case of air within vases. *Social Education Research*, *6*(1), 69-79. https://doi.org/10.37256/ser.6120255862

Kottara, A., Dimitrakou, M., & Starakis, I. (2024). Elementary students' understanding about how convex lenses affect light propagation. *Education Sciences*, *14*, 432. https://doi.org/10.3390/educsci14040432

Mabejane, M. R., & Ravanis, K. (2018). Linking teacher coursework training, pedagogies, methodologies and practice in schools for the undergraduate science education student teachers at the National University of Lesotho. *European Journal of Alternative Education Studies*, *3*(2), 67-87. http://dx.doi.org/10.46827/ejae.v0i0.1967

National Research Council. (2011). *Successful K-12 science education: identifying effective approaches in science, technology, engineering and mathematics*. The National Academic Press. https://doi.org/10.24297/jap.v2i1.2103

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. https://doi.org/10.17226/13165.

Nertivich, D. (2013). Magnetic field mental representations of 15-16 year old students. *Journal of Advances in Physics*, *2*(1), 53-58. http://dx.doi.org/10.24297/jap.v2i1.2103

Petrovici, C. (2008). Résultats d'une enquête sur les compétences et les rôles essentiels des instituteurs. *Review of Science, Mathematics and ICT Education*, *2*(1/2), 97-109. Retrieved from https://www.researchgate.net/publication/45087865_Resultats_d'une_enquete_sur_les_competences_et_les_roles_essentiels_des_instituteurs

Ravanis, K. (2013). Mental representations and obstacles in 10–11-year-old children's thought concerning the melting and coagulation of solid substances in everyday life. *Preschool and Primary Education*, *1*(1), 130-137. https://doi.org/10.12681/ppej.38

Ravanis, K. (2020). Precursor models of the Physical Sciences in Early Childhood Education students' thinking. *Science Education Research and Praxis*, *76*, 24-31. https://serp.ecedu.uoi.gr/wp-content/uploads/2022/07

Ravanis, K. (2021). The Physical Sciences in Early Childhood Education: theoretical frameworks, strategies and activities. *Journal of Physics: Conference Series*, *1796*, 012092. https://doi.org/10.1088/1742-6596/1796/1/012092

Ravanis, K. Papamichaël, Y. & Koulaidis, V. (2002). Social marking and conceptual change: the conception of light for ten-year old children. *Journal of Science Education*, *3*(1), 15-18. Retrieved from http://150.140.160.55:8000/static/magazine/international/2020/12/07/2002_-_Ravanis_Papamichael_Koulaidis.pdf

Ravanis, K. Zacharos, K. & Vellopoulou, A. (2010). The formation of shadows: the case of the position of a light source in relevance to the shadow. *Acta Didactica Napocensia*, *3*(3), 1-6. https://eric.ed.gov/?id=EJ1056131

Ravanis, K. Charalampopoulou, C. Boilevin, J.-M. & Bagakis, G. (2005). La construction de la formation des ombres chez la pensée des enfants de 5-6 ans: procédures didactiques sociocognitives. *Revue de Recherches en Éducation: Spirale*, *36*, 87-98. https://www.persee.fr/doc/spira_0994-3722_2005_num_36_1_1327

Rodriguez, J. (2018). Des représentations aux premiers modèles: le monde physique dans la pensée des petits enfants. *European Journal of Education Studies*, *5*(2), 1-9. http://dx.doi.org/10.5281/zenodo.1410643

Rodriguez, J., & Castro, D. (2014). Children's ideas of changes in the state of matter: Solid and liquid salt. *Journal of Advances in Humanities*, *1*(1), 1-6. https://doi.org/10.24297/jah.v1i1.5151

Rodriguez, J., & Castro, D. (2016). Changing 8-9 year-old pupil's mental representations of light: a metaphor based teaching approach. *Asian Education Studies*, *1*(1), 40-46. Retrieved from https://hal.science/hal-02488588/document

Rodriguez, J., & Castro, D. (2020). Quality improvement in teaching and learning science in primary school settings: using a metaphor to approach the concept of light. *Jurnal Ilmiah Pendidikan Fisika Al-BiRuNi*, *9*(2), 185-194. http://dx.doi.org/10.24042/jipfalbiruni.v9i2.6141

Sotirova, E.-M. (2017). L'apprentissage en sciences expérimentales : la recherche et l'enseignement. *European Journal of Education Studies*, *3*(12), 188-198. https://doi.org/10.5281/zenodo.1117928

Sotirova, E.-M. (2020). Réflexions sur les objectifs de l'éducation scientifique. *European Journal of Education Studies*, *7*(2), 172-180. https://doi.org/10.5281/zenodo.3726312

Sotirova, E.-M. (2024). Représentations mentales, obstacles et enseignement des sciences physiques. *European Journal of Education Studies*, *11*(3), 154-165. http://dx.doi.org/10.46827/ejes.v11i3.5244

Tin, P. S. (2016). Peuvent-ils les enfants de l'âge préscolaire construire un modèle pour la flottaison et l'immersion? *International Journal of Progressive Sciences and Technologies*, *4*(2), 72-76. Retrieved from https://ijpsat.org/index.php/ijpsat/article/view/90

Tin, P. S. (2022). Représentations mentales et obstacles dans la pensée des enfants de 6 et 11 ans sur la fusion de la glace. *European Journal of Education Studies*, *9*(3), 130-139. http://dx.doi.org/10.46827/ejes.v9i3.4209

Voutsinos, C. (2013). Teaching Optics: light sources and shadows. *Journal of Advances in Physics*, *2*(2), 134-138. http://dx.doi.org/10.24297/jap.v2i2.2100

Yurumezoglu, K. (2009). An entertaining method of teaching concepts of linear light propagation, reflection and refraction using a simple optical mechanism. *Physics Education*, *44*(2), 129-132. http://dx.doi.org/10.1088/0031-9120/44/2/002