



THE RAINBOW IN THE THINKING OF PROSPECTIVE KINDERGARTEN TEACHERS

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Abstract:

In the current study, the representations of kindergarten prospective teachers on the rainbow formation phenomenon as well as their interest in implementing rainbow-related activities in their teaching were explored. This study is part of a research perspective that aims to document the difficulties of Early Childhood Education teachers in Physical and Biological Sciences. Rainbow topic was chosen as on the one hand it is often included in curricula along with various other visual phenomena and on the other hand, there is no related research that focuses on teachers' views about this phenomenon. The research was qualitative and exploratory in nature and was conducted through a semi-structured interview. From data analysis it was found that the kindergarten prospective teachers of the sample have structured mental representations about rainbow which are far from school scientific knowledge. At the same time, they consider the rainbow to be an interesting topic for developing teaching activities in the classroom.

Keywords: early childhood science education, mental representations, beliefs, kindergarten prospective teachers, rainbow

1. Introduction

Over the last 30 years, among different scientific fields such as Early Childhood Education, Science Education and Cognitive and Genetic Psychology, there has been strong research interest in a whole range of issues related to the introduction of children aged 3-8 years to the study of materials and entities of the natural world, natural phenomena and science in general. Thus, some efforts are directed towards the creation or study of relevant curriculum modules (Adbo & Vidal Carulla, 2019; Ampartzaki, Kalogiannakis, & Papadakis, 2021; Saçkes, Trundel, & Shaheen, 2020), other research is

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carried out on the difficulties of constructing natural entities and natural phenomena in the minds of young children (Kaliampos et al., 2020; Pantidos, Herakleioti, & Chachlioutaki, 2017; Paños, Martínez Rodenas, & Reyes Ruiz-Gallardo, 2022; Ravanis, 2017, 2021; Skopeliti, Thanopoulou, & Tsagkareli, 2018) while other efforts are directed towards issues related to teachers such as their knowledge, beliefs and practices (Draganoudi, Lavidas, & Kaliampos, 2021; MacDonald et al. 2021; Papandreou & Kalaitzidou, 2019; Vartuli, 1999; Zotti & Fragkiadaki, 2021).

This last orientation of efforts is always of particular interest as the teacher is the decisive factor in any teaching process. One of the important research topics related to teachers of early childhood education is their readiness regarding the field of developing activities in the classroom on specific teaching subjects such as physical sciences. Undoubtedly, this issue is closely related to their studies, the level and organization of which significantly influence teachers' knowledge and therefore their teaching strategies.

2. Theoretical Framework

In general, research on teacher knowledge can be divided into two directions: perceived knowledge, i.e. a kind of opinion or belief, and actual knowledge, i.e. representations or mental representations. Perceived knowledge-belief refers to the amount of convincing information in a particular orientation that someone has about a target issue (Tormala & Petty, 2007; Vellopoulou, & Ravanis, 2012). Actual knowledge-representations are a direct and clear awareness of certain parameters such as facts and their conditions of existence (Ergazaki & Zogza, 2012; Hindarti et al., 2021; Jelinek, 2021; Kambouri, 2016; Kampeza et al., 2016; Ravanis, 2020). Perceived knowledge thus falls under the metacognitive domain while actual knowledge under the cognitive domain (Dori & Avargil, 2015). Indeed, a strong link seems to exist between teachers' practices and beliefs and/or representations of various educational issues as well as the way they interpret and conceptualize science, education, societies, and the world in general (Fang, 1996).

The issue of the way human thought approaches natural phenomena in general as well as the concepts of the natural sciences is the subject of systematic research. One finding of general agreement among the scientific community is that the approach to the natural world by human thought is achieved through the construction of mental entities identified in the literature as ideas, alternative conceptions, representations, misconceptions etc. These entities are created in thought experientially under the influence of the natural and wider social environment and, despite the school path of students, are very often very far from school scientific knowledge, i.e. scientific knowledge that is appropriately transformed to become an object of learning in school (Boilevin et al., 2020; Dumas Carré et al., 2003; Elmalı & Laçın Şimşek, 2021). This issue is very important for teachers who will eventually be called upon to teach Physical or Biological Sciences as they will find themselves in an apparent contradiction between the entities of their thinking with which they approach natural phenomena and concepts and the school curriculum they will have to manage in their classrooms. Therefore, studying

these representations of teachers is of particular importance as they can highlight what is useful and necessary to teach and study during initial and continuing training.

This issue is prominently becoming relevant for Early Childhood Education, as Natural Sciences activities are gradually appearing in curricula all over the world (French, 2004). However, there seems to be little data on kindergarten teachers' actual knowledge, as there is very little research on the subject. For example, Cruz-Guzmán García-Carmona and Criado (2020) studied the school-level scientific models proposed by prospective pre-primary teachers about the water molecule and its intermolecular bonds, and their representations of different states of water molecule aggregation at a microscopic level or Baysen (2016) studied the misconceptions of early childhood teacher candidates on the rules for the disappearance of astronomical objects and materials.

Along this line, in this study were explored representations of prospective kindergarten teachers regarding the natural phenomenon of the rainbow. From a scientific perspective, the rainbow is the result of light being refracted and reflected by rain droplets which act as prisms in the atmosphere. Therefore, the following two conditions should be fulfilled in order for a rainbow to appear; there must be sunshine at the time the rain stops or a few sprinkles fall and the sun must be behind the observer (Hewitt, 2015).

The visual phenomenon of the rainbow has been little studied in the international literature with the research mainly focusing on children's reasoning. Kikas (2010) studied the explanations for the formation of a rainbow of Estonia students aged 8 to 11 years old. Her findings showed that children tended to combine everyday experiences with some basic knowledge of Geometrical Optics thus activating a kind of synthetic representations. In addition, Siry and Kremer (2011) investigated the representations of the rainbow phenomenon in 5–6-year-old children in Luxembourg. The results showed that children's responses to questions about the rainbow were based on everyday experiences. Malleus, Kikas and Kruus (2016) in Estonia and Wilhelm and Henninger (2012) in Germany attempted to investigate primary school students' representations of rainfall, clouds and rainbow formation. In this study also, children from all primary education classes confronted difficulties in explaining the rainbow formation and tended to formulate similar synthetic responses. Finally, Hast's (2020) research through small group discussions among English children aged 5, 8 and 11 attempted to capture their representations of the rainbow and its formation. The findings of the research showed that the younger children's understanding was largely inaccurate or limited, while the older age groups were more able to demonstrate sophisticated forms of understanding.

Nevertheless, as soon as we want the activities developed in classrooms by kindergarten teachers to be effective, we should be aware not only of the representations of young learners but also the representations and the beliefs of the teachers themselves, so that we can organize their training appropriately.

In this context, the research questions posed in the current paper correspond to:

1. the recording and classification of representations of students - prospective kindergarten teachers about the rainbow phenomenon and,

2. the study of students' views on whether rainbow is considered as a topic on which classroom activities could be implemented.

3. Methodological framework

The current study is qualitative in nature and aspires to explore and classify teachers' representations and beliefs about the rainbow. For this purpose, a descriptive research design was employed using interviews as a research tool (Creswell, 2015). In particular, a semi-structured interview consisting of 6 open-ended questions was developed to address the research questions. The interviews were conducted on an individual basis, each one lasted 10-15 minutes and were recorded. Audio documents were transcribed and data analysis was conducted from these transcripts.

At the study took part 30 female prospective kindergarten teachers of the Department of Educational Sciences and Early Childhood Education of the University of Patras in Greece. These students were in the 3rd year out of four years of compulsory studies and had a special interest in Physical Sciences. The students had taken a 4-6 semester course in Physical and Biological Sciences, but had not been introduced to the rainbow phenomenon. They participated voluntarily after a public invitation.

4. Results

In what follows, the results obtained from the analysis of students' responses through the interview process are presented. The results are given for each research question and interview question separately. Apart from the tables that depict the frequency of responses, typical examples of answers for each category are also given.

4.1. First research question: what are the students' representations of the rainbow phenomenon as recorded in their responses?

4.1.1. Question 1: How is the rainbow created? Please give a brief explanation.

In this question 'compatible with school knowledge' were classified responses where it was recognised that the rainbow is the result of the refraction and reflection of light in the rain droplets that are present in the atmosphere and act as prisms. For example, "*When the sun's rays fall on the rain droplets, refraction and reflection will occur*" (Student 2 - S.2). Responses that attributed the creation of the rainbow to the fact that sunlight simply reflects off the rain droplets were marked as "*partially compatible with school knowledge*". For example, "*The rays of sunlight that are white, transparent are reflected in the rain droplets*" (S.5). Finally, responses that simply described the presence of the rainbow or elements of the rainbow were marked as 'incompatible with school knowledge'. For example, "*... I guess it is created after rain and it seems to me that somehow the sun rays that pass through the raindrops play a role*" (S.28).

The table below shows frequencies of students' responses to question 1.

Table 1: Frequencies of students' responses to question 1

Response Category	Frequencies	Percentages %
Compatible with school knowledge	5	16.6%
Partially compatible with school knowledge	17	56.7%
Incompatible with school knowledge	8	26.7%

4.1.2. Question 2: Which elements are involved in the creation of the rainbow?

In the second question, 'compatible with school knowledge' were classified responses that identified both the existence of sunlight and rain as well as the clouds that create rain as necessary elements for the formation of rainbow. In those answers, there was an overall reference to the specific atmospheric situation that is apparent during rainbow creation. For example, *"The sun's rays, the rain and the clouds"* (S.25). Responses that simply mentioned the sun and rain as elements were classified as 'partially compatible with school knowledge'. For example, *"The sun... and the rain"* (S.5). Finally, responses that included items that were not related to the creation of the phenomenon were marked as 'incompatible with school knowledge'. For example, *"...the air, the sun, the plants..."* (S.1).

The table below shows frequencies of students' responses to question 2.

Table 2: Frequencies of students' responses to question 2

Response Category	Frequencies	Percentages %
Compatible with school knowledge	4	13.3%
Partially compatible with school knowledge	22	73.4%
Incompatible with school knowledge	4	13.3%

4.1.3. Question 3: What is the role of sun and rain in the creation of rainbow?

In the third question, 'compatible with school knowledge' were classified answers in which reference was made to the phenomena of reflection and refraction of sunlight in raindrops while the appearance of different colours was attributed to these phenomena. For example, *"I guess that the sunlight penetrates the water and creates refraction and reflection due to the fact that rain is being transparent. The rain acts as a prism that is necessary for the sun's rays to pass through and create the colors"* (S. 27). Answers where a reference was made to reflection or refraction, without any specific mechanism for rainbow creation were marked as 'partially compatible with school knowledge'. For example, *"The rays of the sun are reflected from the raindrops. Consequently, both the sun and the rain are needed for reflection"* (S.11). Finally, 'incompatible with school knowledge' were classified answers in which there was no reference to the phenomena of reflection or refraction at all. For example, *"The rays of the sun will help to create the rainbow. But I don't know how they will do so... maybe the water vapor that comes from rain merge with sunlight in order to create the lines of the rainbow"* (S.28).

The table below shows frequencies of students' responses to question 3.

Table 3: Frequencies of students' responses to question 3

Response Category	Frequencies	Percentages %
Compatible with school knowledge	4	13.4%
Partially compatible with school knowledge	14	46.6%
Incompatible with school knowledge	12	40%

4.1.4. Question 4: How are different colors formed in the rainbow?

With the fourth question, an attempt was made to explore whether students were able to describe in an accurate way the mechanism of refraction. Here there were found no answers that could be classified as 'compatible with school knowledge'. In contrast, there were answers where students approached the mechanism of sunlight refraction in drops without being able to do this in an accurate way though. These responses were consequently marked as 'partially compatible with school knowledge'. For example, *"The rays of sunlight falling on rain make a reflection. The sun falls on different parts of the drop, so it is refracted on different sides"* (S.9). The 'incompatible with school knowledge' responses were those where students did not suggest a mechanism for colour creation related to refraction, often identifying the phenomenon as a matter of vision. For example, *"It has to do with the way each person sees it... the way it is reflected in his eyes. There are no colours in reality"* (S.9).

The table below shows frequencies of students' responses to question 4.

Table 4: Frequencies of students' responses to question 4

Response Category	Frequencies	Percentages %
Compatible with school knowledge	0	0%
Partially compatible with school knowledge	8	26.7%
Incompatible with school knowledge	22	73.3%

4.2. Second research question: what are students' views on the development of classroom activities on rainbow phenomenon?

4.2.1. Question 5: Do you think that rainbow-related activities can be implemented in kindergarten?

In the fifth question, an attempt was made to explore the way students perceive the possibility of organizing rainbow-themed activities in kindergarten. Their answers clearly indicated the view that the rainbow can be the subject of activities in kindergarten. Thus, almost all of them expressed in an extremely positive way about such a prospect. Indicatives are the following answers *"I think they can because children already possess pre-existing knowledge about the rainbow that is not necessarily correct. Therefore, we can build on their knowledge to help them move towards a more scientific approach"* (S.14) or *"yes, because it can be approached in an interdisciplinary way; that is both in visual arts and science as well as in drama education"* (S.22). Only one student was negative as she acknowledged that the phenomenon is complex. To quote his/her response *"it is very difficult to be understood by children of that age. Teaching the phenomenon of rainbow requires the support of strong scientific data while children face difficulties in conceptualizing such scientific concepts"* (S.15).

The table below shows frequencies of students' responses to question 5.

Table 5: Frequencies of students' responses to question 5

Response Category	Frequencies	Percentages %
Positive belief	29	96.7%
Negative belief	1	3.3%

4.2.2. Question 6: Would you implement rainbow-related activities as prospect teachers?

Students' responses here confirmed in the most emphatic way their positive belief recorded in the previous question. Specifically, the vast majority of them stated that they would implement rainbow-related activities in their future classes. However, despite their generally positive belief, they often stressed the need to study the characteristics of the phenomenon more in-depth as they do not feel well prepared. For example, *"I would try to study and then implement activities in kindergarten"* (S.29) or *"yes, I will do it as soon as I conceptualize how it is created. I haven't been taught about this phenomenon since primary school and to be honest I don't remember much anymore"* (S.3). Quite interestingly, two female students had a negative belief, citing the difficulty of the phenomenon. To quote one of them *"it seems to me a difficult subject which I cannot approach properly so that it can be understood by my students. Firstly, I need to learn about this phenomenon by myself as I have never heard anything about rainbow since primary school"* (S.10).

The table below shows frequencies of students' responses to question 6.

Table 6: Frequencies of students' responses to question 6

Response Category	Frequencies	Percentages %
Positive belief	28	93.4%
Negative belief	2	6.6%

5. Discussion

The current article presents the results of an investigation of students-prospective kindergarten teachers' ideas, regarding, on one hand, their representations of the rainbow and on the other hand their beliefs towards the way this phenomenon could be implemented in their future classroom activities. This research is part of a perspective that aims to approach the relationship between the constitutive knowledge of Physical Sciences in teachers' thinking and their beliefs towards the possibility of developing relevant teaching activities (Draganoudi et al., 2021; Papandreou & Kalaitzidou, 2019; Vartuli, 1999; Zotti & Fragkiadaki, 2021).

Thus, in the first research question, students' representations of the rainbow phenomenon itself were studied. Particularly, in a series of questions that attempted to capture the relationship of representations of the rainbow phenomenon as it is approached in school knowledge, it was found that only about 1/8 students referred to the formation of this phenomenon in terms of reflection and refraction of sunlight on raindrops. The descriptions given by these students were consistent with school knowledge, although their interpretations regarding the formulation of the different

colours that appear in a rainbow were not satisfactory. Nevertheless, quite interestingly almost 1/4 to 3/4 of students' responses among all research questions were partially compatible with school knowledge. This finding underlines the potential possibility of transforming students' ideas to representations compatible with school knowledge as long as they are taught the basics of Geometrical Optics in a systematic way.

The issues related to kindergarten teachers' representations have been thoroughly discussed in the literature and are closely related to both their undergraduate and postgraduate studies. Indeed, as in the case of the present study, research often shed light on the difficulties that arise in schematizing knowledge from Physical Sciences (Convertini, 2021; Kavalari et. al., 2012). Undoubtedly, these findings directly raise the broader issue of initial and continuing training programmes for kindergarten teachers in Physical and Biological Sciences. Once these difficulties are considered along with the findings of the second research question, which underline a very positive belief towards the implementation of rainbow-related activities in kindergarten, the difficulty in creating quality activities that lead to the effective initiation of young children in Science and Biological Sciences becomes evident. Along with this perspective, the subject of the current research is often discussed in the relevant literature (Kornelaki & Plakitsi, 2018; Pereira et al., 2020; Sesto & García-Rodeja, 2021).

The findings of the current research clearly show that while prospective kindergarten teachers hold a very positive belief towards the possibility of developing rainbow-related activities, they face difficulties with the teaching material itself as their representations are distanced from the scientific knowledge that favors the reflection and refraction of sunlight on water drops remaining in the atmosphere. It becomes evident that the rationalisation of the process of generating appropriately trained kindergarten teachers requires the development of curricula that are based on the necessary knowledge transformation from Physical and Biological Sciences in a way that could be conceptualized by prospect teachers themselves. Indeed, these choices should be adapted to the needs and potential of the early childhood education young learners themselves. Along this direction, there is certainly a wide field of research that requires a systematic and steady way of converging different fields of research such as Early Childhood Education, Science Education and Cognitive Psychology that would lead to the development of an interdisciplinary field of basic and applied research.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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