Preservice Physics Teachers' Challenges in Laboratory Practice

İrem GEZER, Simay KÖKSALAN, Ufuk YILDIRIM

Middle East Technical University

4th World Conference on Physics Education 2024

Krakow, Poland

OUTLINE

- Why are laboratory activities important in science education?
- Research Questions
- Methodology
- Result
- Discussion and Recommendation

Why are laboratory activities important in science education?

- Inquiry-based learning in science education focuses on developing science process skills and gaining a deeper understanding because learners actively experience the phenomena (Biswal & Behera, 2022; Barman, 2002; *Inquiry and the National Science Education Standards*, 2000).
- Laboratory activities play an important role in science curricula because they contribute to the deep understanding of phenomena and the process of constructing knowledge (Gericke et al, 2023; Hofstein,2017; Wellington, 1998).
- Even though laboratory practices promote pre-service teachers (PPTs), in gaining both conceptual understanding and science process skills, learners and teachers may encounter challenges. (Demirtaş, 2024; Gericke et al, 2023).
- The studies stated that teachers faced challenges in the implementation of the objectives in the high school physics curriculum that emphasizes learning based on doing experiments and inquiry-based in Türkiye (Sartaş, 2024; Büyükbayraktar-Ersoy, 2018; Akdeniz et al, 2012).
- Note that laboratory practices are important for PPTs as they have the potential to impact their future students.

Research Questions

- RQ1: What are the challenges faced by PPTs in utilizing different experimental methods in an inquiry-based laboratory activity about image formation in plane mirrors?

- RQ2: How do these challenges impact their conceptual understanding and science process skills?

- RQ3: What are the perceptions of PPTs regarding the influence of utilizing different experimental methods in an inquiry-based laboratory activity about image formation in plane mirrors on their conceptual understanding and scientific process skills?

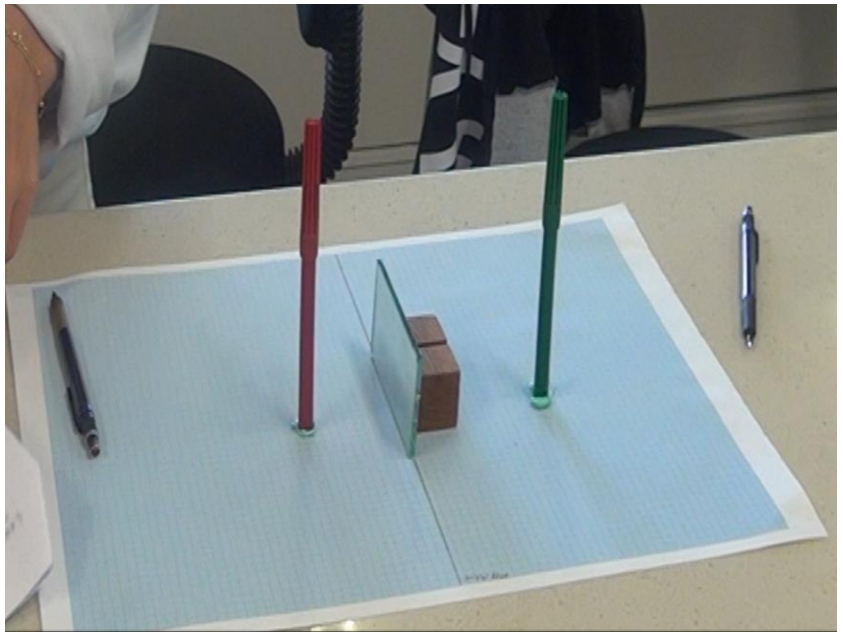
Methodology

- Sample:
  - 8 PPT's (senior undergraduate physics teachers)
- Materials:
  - Laboratory Manual, Laboratory Equipments Used in Experiment
- Data Sources:
  - Video Recordings during Lectures, Voice Recordings during Interviews, Quizzes, Laboratory Reports, Observation Notes

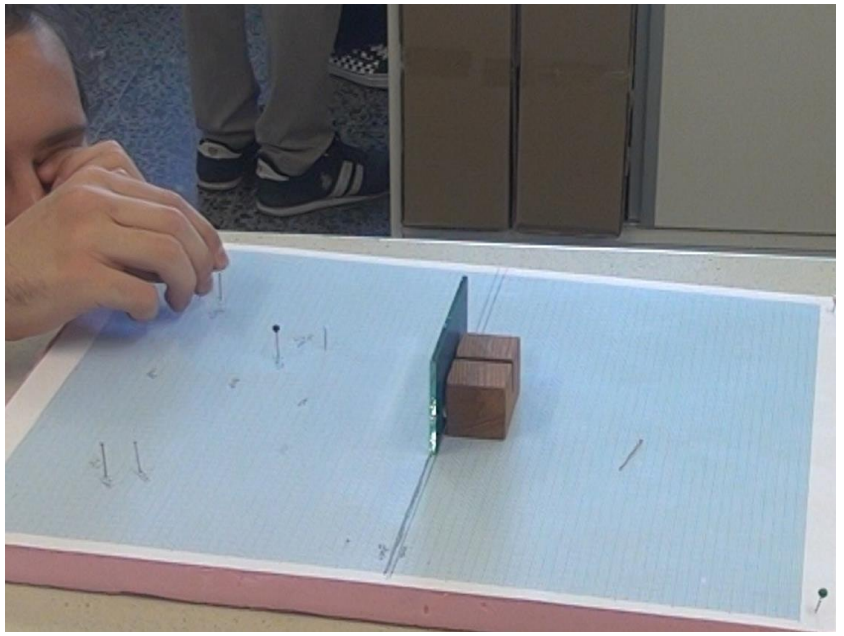
Methodology

- In this experiment, PPTs investigate image formation on a plane mirror. For this purpose, they investigate the phenomena by utilizing the different experimental methods: parallax and ray tracing.

- Parallax Method



- Ray Tracing Method

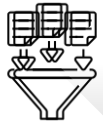


Result- Chain of Challenges

Following experimental procedure (1)

Constructing experimental setup (2)

Observing the phenomena (3)

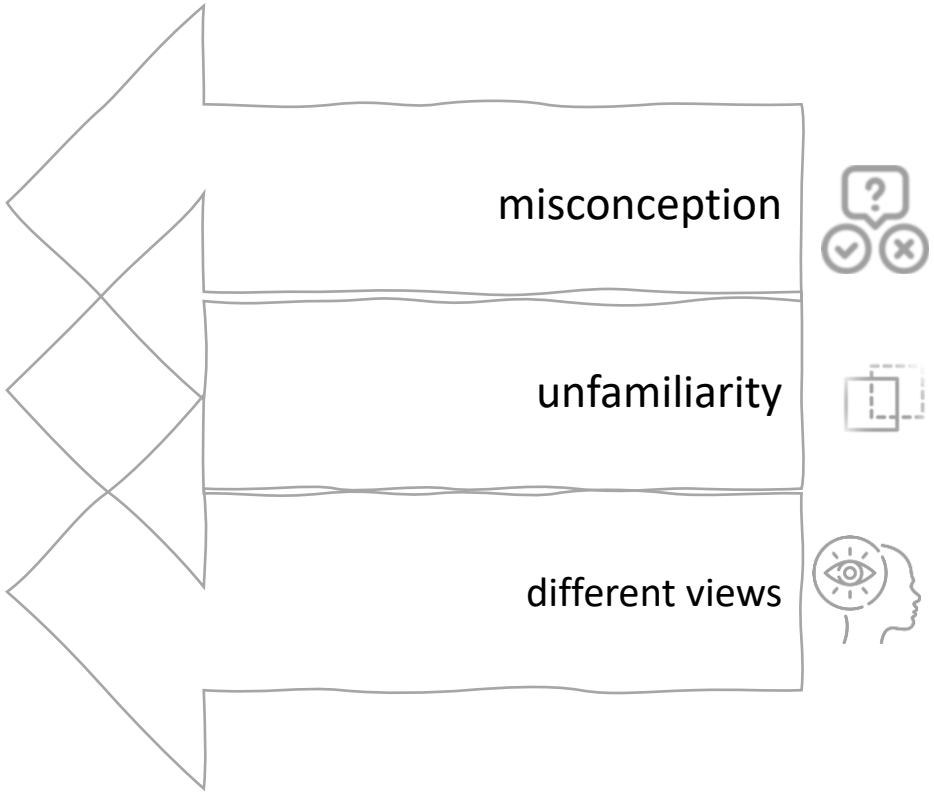


Collecting data from each method in the experiment (4)

Interpreting the data obtained from experiment (5)

Compare and contrast the prior and new knowledge (6)

Building a conceptual understanding about the phenomena (7)



Result- Challenges of PPTs

	Explanation	Example
Challenges of experimenting (cover 1 and 2)	Understanding and following experimental procedure	*"The experiment sheet was understandable, but in the second part (ray tracing method) I did not understand which image I had to close."*
	Building experimental setup	"*Positioning the mirror and keeping it upright in both parts was complicated*."
Challenges of collecting the data (cover 3 and 4)	Observing the phenomena by sense (eyes)	*"In the second part (ray tracing method) the object and its image do not appear symmetrically because the location of the image in the plane mirror changes relative to my eyes' position."*
	Using experimental equipment and measuring data	*"In the first part (parallax method), we didn't know how to position the pen to find the location of the image. Perhaps a different material could have been used...there is a margin of error in the data taken close to the mirror, but this is changing (either object-mirror distance or image-mirror distance)…"*
Challenges of interpreting the data (cover 5)	Understanding what the data set said	*"Theoretical knowledge is always correct. Since I already know the theoretical information, I can be confident in the data and interpret them. If I had not known, I would not have interpreted them."*
	Organizing the data obtained from different methods	*"We applied both methods but we did not compare the results we obtained, we did not feel the need. But I can say that the image is behind the mirror for both of them."*

Result- Challenges of PPTs

	Explanation	Example
Challenges of questioning **(cover 6)**	Questioning the reasons for the phenomena	*"I did not understand what the line I drew by covering two different points of the mirror image of the object with needles was."*
	Be questioned about the basis of what they observe	*"When I am questioned during the experiment, I wonder if we are making a mistake. When you are involved in the experiment by questioning it, the experiment does not feel like it belongs to us..."*
Challenges of constructing conceptual understanding **(cover 7)**	Knowledge delivery and acquisition	*"The image is formed behind the mirror at the same size as the object."* *"The virtual image is always upright. That's how we learned it and that's how we observed it. I don't know how it was formed."* *"The virtual image is upright. This is how they defined the virtual image... I can't explain it by making an inference from the experiment, or I can't draw the rays..."*

Result- Perception of PPTs

	Using Parallax Method	Using Ray Tracing Method
Surprise and Discovery	"*I didn't think I could **discover** image formation by experiment, it could only be explained by theoretical knowledge. That's why the experiment was so **surprising** to me...*"	"*I knew the theory but I was **very surprised** when I saw the image being created with drawing, especially in the second method…*"
Curiosity and Engagement	"*Finding the location of the image behind the mirror by observation aroused **curiosity** for me*."	"*It was **fun to engage** to find the location of the image by covering it!*"
Enjoyment and Fun	"*Finding the location of the image using the parallax method seemed **like a game to me***."	"*…the ray tracing method was more **enjoyable** as I liked seeing how the rays intersect*"
Understanding and Visualization	"*While the parallax method is **good for understanding** the image…*"	"*Normally we can't see light rays like that (ray model), but it was **very interesting to draw it** here*."
Scientific Perception	"*The first part is completely observation, based on our experience. You **can't show any evidence***."	"*I think the ray tracing method is **more scientific** because we are drawing rays **like a graphic**…*"

Discussion and Recommendation

- The challenges faced by PPTs are experimenting, data collection, data interpretation, questioning, and conceptual understanding.
- PPTs' perceptions varied in terms of surprise and discovery, curiosity and engagement, enjoyment and fun, understanding and visualization, and scientific perception.
- PPTs generally have positive views on taking laboratory courses because such courses help them understand their future students better and prepare them better when they become teachers in the future.
- This result might support that the challenges experienced by PPTs may vary on the context-bond used in the experiment because of different methods utilized in the experiment even on the same topic.
- Teacher candidates can face challenges in inquiry-based activities, so identifying and addressing these challenges is important to better prepare them for their future roles as educators.
- It is important to be aware of the challenges faced by pre-service teachers and to design such inquiry-based laboratory courses for pre-service teachers.

Reference

Akdeniz, A. R., & Paniç, G. (2012). Yeni fizik öğretim programına ve uygulamasına yönelik öğretmen görüşleri. *Milli Eğitim*, *196*, 290–307.

Barman, C. R. (2002). How do you define inquiry? *Science and Children*, *40*(2), 8–9.

Biswal, S., & Behera, D. B. (2022). Enhancing Science Process Skills through Inquiry—Based Learning: A Comprehensive Literature Review and Analysis. *International Journal of Science and Research*, *12*(8).

Büyükbayraktar-Ersoy, F. N., Karamustafaoğlu, O., & Özdoğan, T. (2018). Araştırmacı sorgulayıcı fizik öğretim programının uygulanmasında öğretmenlerin karşılaştığı sorunlar. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, *15*(1), 1–20.

Demirtaş, D. (2024). *Challenges of pre-service physics teachers in argument-driven inquiry activities* [Doctoral Dissertation]. Middle East Technical University.

Gericke, N., Högström, P., & Wallin, J. (2023). A systematic review of research on laboratory work in secondary school. *Studies in Science Education*, *59*(2), 245–285. https://doi.org/10.1080/03057267.2022.2090125

Hofstein, A. (2017). The role of laboratory in science teaching and learning. In K. S. Taber & B. Akpan (Eds.), *Science Education* (pp. 357–368). SensePublishers. https://doi.org/10.1007/978-94-6300-749-8_26

Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. (2000). National Academies Press.

Sartas, F. (2023). *Evaluation of the implementation of the 10th grade high school physics curriculum* [Master]. Middle East Technical University.

Wellington, J. (Ed.). (1998). *Practical Work in School Science: Which Way Now?* Routledge.

Thank you very much for your attention.

I would be glad to try and answer any questions.

İrem GEZER
kuli@metu.edu.tr

Simay KÖKSALAN
simay@metu.edu.tr

Ufuk YILDIRIM
yufuk@metu.edu.tr