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ENHANCING PRESERVICE TEACHERS' SCIENCE TEACHING EFFICACY BELIEFS THROUGH ROLE-PLAY

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Abstract
Role-play simulations remain an engaging and easy way to model real-world connections to classroom learning environment but remains an underutilized strategy by many educators. Most studies have supported the benefits of role play such as reinforcing authentic class content and improving learning outcomes as well as promoting inclusivity through multiple perspectives. In this study we investigated the impact of role-play simulation in a science methods course with pre-service teachers using reflections collected after completing a role play simulation activity. In our findings we established that role-play is both an engaging activity and helps in bringing multiple perspectives into a learning environment while simulating real world connections. Also, the pre-service teachers reported that it is a pedagogical strategy they would adopt in their future classrooms
Keywords: Role Play, Simulations, Environmental Science, Pre-service Teachers, Multiple Perspectives.

I. Introduction

For a better understanding of science and scientific concepts, science teachers must reengineer the traditional strategies for teaching science. The National Academies of Sciences, Engineering, and Medicine (1996) noted that scientific fact and/or knowledge-oriented science teaching focuses narrowly on the laws, concepts, and theories of science. These methods do not lead to an understanding of how science itself works or how the scientists arrived at those conclusions. Science teachers should use different learning activities to assist learners in developing practical skills which will include reading and research assignments, class discussions, case studies, and practice sessions. These activities are even more powerful when connected to real-life situations and the acquisition of real-life skills. Real-world skills often begin in a classroom where students master concepts and abilities that will equip them with knowledge and skills for their professional careers. Students can develop these skills through various activities, but perhaps one of the most important ways to master these skills to ensure the transfer of learning is through experiential learning activities (Cronin & Connolly, 2007).

Experiential learning refers to learning through experience and reflection on the activity. One way to provide students with such experiential learning opportunities is through role-playing (Chau et al., 2013). Role-playing is beyond the learning of mere facts. It enables the creation of circumstances for effective learning through communication, cooperation, improvisation, and argumentation. It allows more opportunities for students to engage in an interactive dialogue and to construct meaning together with the teacher in an active role (Spink et al., 2005). If properly designed, the use of role-play-oriented activities in the primary years can contribute to the enjoyment of science and ultimately to the development of a better understanding of science (Cakici & Bayir, 2012).

Role-playing is a powerful tool for placing students into a "real world" context for the purpose of reinforcing class content and improving learning outcomes (Wedig, 2010). Giving students agency to make decisions within the realistic constraints faced by governments affords them the opportunity to make practical and difficult decisions regarding budget allocation. In this paper, we report how preservice teachers (PSTs) engaged in role-play to simulate decision-making about an environmental issue.

II. Literature Review

Teacher Candidates' Beliefs and Self-efficacy in Science

Ramsey-Gassert and Shoyer (1998) suggested that teaching self-efficacy beliefs refers to teachers' confidence in their own teaching abilities which is reflected in their teaching behaviors. Yürük suggests that there are various factors that predict pre-service teacher anxiety toward teaching science, including low self-efficacy, limited science background knowledge, and a lack of strong role-models for teaching science (2011). Preservice elementary methods courses should offer a different approach to science teaching as a means of increasing science teaching self-efficacy. To improve the ability, effectiveness, and feelings of success in elementary teachers, science educators need to include strategies to improve attitudes toward science and increase teaching self-efficacy in teacher preparation courses. According to Cetin-Dindar (2022), science teacher educators should use more student-centered teaching approaches so that pre-service science teachers can experience the approaches themselves. Additionally, inquiry-based laboratory activities should be increased so that pre-service science teachers can follow their educators as role models and their teaching self-efficacy beliefs can be increased via vicarious experiences and in-service science teachers who have a higher sense of efficacy for student engagement relate science to real-life experiences more than pre-service science teachers. More opportunities should be provided in both contexts to increase their teaching experience (2022).

Yezdan & Cetin-Dindar (2021) state when students are motivated to learn science, they are more focused on content and achieve meaningful learning. Therefore, in teacher education programs, pre-service science teachers should be instructed in constructivist learning environments where science is related to daily life, students are encouraged to think out loud about scientific activities and learning processes, and students feel free to express their own thoughts. Moreover, pre-service science teachers should be encouraged to provide constructivist learning environments during their teaching practices. By engaging the preservice elementary teachers in scientific inquiry projects related to the real world in science content courses, the teacher candidates would have multiple opportunities to develop their understanding of science and scientific inquiry and, therefore, would be more likely to develop more positive attitudes toward science and become more confident and effective in teaching inquiry-oriented science to their future students (Liang & Richardson, 2009).

Benefits of Role-play as a Teaching Strategy

Howes and Cruz (2009) summarize that using role-playing in science education can be beneficial in several ways. It can lead to more authentic learning, develop multiple perspectives, and help preservice teachers practice and sharpen their presentation skills. Although some of the lessons learned by prospective teachers might be seen as simplistic, this may be the beginning of larger shifts in thought. Incorporating marginalized groups into the teaching of science can help students conceptualize science in a more inclusive manner while developing empathy and understanding of the relative challenges and opportunities of living in another era or different culture, working with ongoing barriers put up by a highly prescribed and often still prejudiced field. Wulandari (2018) adds to this by stating the use of role-playing in the learning process is excellent for conceptual understanding. It also contains unique aspects in which students can freely interact among themselves to create a scenario. The feeling of empathy during this interaction triggers them to share their knowledge with each other.

According to Sherrin (2015), role-playing can cultivate multiple perspectives. Through role-playing, students strive to understand the experiences of others, even if they do not agree with them. Role-playing allows students to imagine the narrative, change a text into real-life, and create alternate scenarios. It gives them the ability to see the potential impact of their choices. Further, he states role-playing helps students to make sense of ideas like power, identity, and choice and acknowledge their humanity.

Additionally, Neuendorf and O'Connell (2011) describe the value of role-plays in teacher education: "Pedagogically sound scenario-based role-plays are activities with a

specific learning outcome designed to create a real learning experience for participants" (p. 2182).

According to the Interdisciplinary Teaching about Earth for a Sustainable Future (InTeGrate, 2022), addressing real-world challenges can enhance the understanding of sustainability issues among students, giving them practical applications for the knowledge and skills acquired in the classroom. By using tangible examples, students can better grasp how these issues directly relate to themselves and society, fostering awareness of the implications of their choices within a broader societal context. Real-world instances also demonstrate the complex and unpredictable nature of problems, promoting critical thinking skills while including the importance of interdisciplinary and multidisciplinary approaches to problem solving. Additionally, utilizing real-world examples emphasizes that there may not be a perfect solution to every problem, encouraging students to focus on exploring potential solutions and the balance of positive and negatives to each outcome rather than just the problem itself.

Oliver (2016) states in the context of environmental sciences, role-play participants may also benefit from the use of the learning techniques to prepare their simulations and develop a deep connection to some of the social science issues that are so difficult to negotiate in real life environmental scenarios, and gain confidence from the self-actualizing achievements that may be associated with this type of transformative practice.

Maharaj-Sharma (2022) found through doing role-play to develop science concepts, that perhaps the most notable benefit of using role-play to teach energy-related concepts in a project was that students' alternative ideas were clarified. These ideas were clarified through either a broadening of prior understandings or by the development of new, "scientifically correct" understandings. Maharaj-Sharma reported that children had a variety of ideas before the role-play but, generally, did not display great concern for the controlled consumption of energy or any great awareness of energy conservation practices.

When questioned after the role-play, it was found that many children had either gained new ideas/understandings leading to a change in their original ideas, or that their original idea/s had broadened to reflect "more scientifically correct" understandings and explanations. The use of common everyday situations in the scenarios allowed students to see the relevance of the learning and the ways in which their understandings could be applied to everyday life situations.

III. Methodology

The Problem

This study sought to answer the questions:

How did the teacher candidates' beliefs change because of a role-play simulation on an environmental issue?

How does role-play simulation promote the engagement and participation of science teaching and learning while providing space for multiple perspectives?

Context and Participants

The role-play scenario was implemented in the Science Methods courses during one semester at Minnesota State University, Mankato, Minnesota, USA. This course is taken during the PST's third year of their undergraduate program to prepare them to be teachers in elementary grades. This investigation involved thirty-eight PSTs. The participants received a pre-instruction text to read about the dilemma they would be exploring during class time. Of thirty-eight PSTs, seven were male, and thirty-one were female. The dilemma was about the Pebble Mine project in Alaska, USA. The Pebble Mine dilemma was a real-world situation around the opening of a Mine in Alaska. Approval for the real-life Pebble Mine project never occurred. However, it was a long-standing, hot-button issue in Alaska and outside.

Preparation for the Role-play Activity

The PSTs participated in a simulation of the debate that occurred around the Pebble Mine in rural, western Alaska. The PSTs were each assigned a specific role (see Table 1) and

given time to research their roles. They collected arguments for and against the Pebble Mine from the viewpoint of their assigned roles. PSTs created a one-minute presentation about their perspective for a fictional Environmental Protection Agency (EPA) meeting. After the presentations, the EPA would vote about proceeding or not proceeding with the Pebble Mine project.

Table 1: Roles assigned to Pre-Service Teachers

Assigned Perspective	**Role**
Community Manager (budgets)	The community manager will act as a liaison between the Mine developer and the community. They will act as the voice and moderator of the developer through community support, distributing important content and any digital media or social media presence to build trust in the Developer through a presence in the community and online.
Mine operator	Part of the crew at the mining site who operates machinery to drill and excavate.
Corporate offices outside of Alaska	Mine Developer – Northern Dynasty Minerals is a Canada-based mineral exploration company. This company was focused on the exploration and advancement of the Pebble Mine project in terms of how feasible it was, permits and development. Proposed profit-sharing plan for the residents from the Bristol Bay region.
Effected Native Corporation officers	Alaska is divided into different corporations. Each corporation is given the right to develop resources in its area.
State legislator	Called on the governor to stop the development of the proposed copper mine.
Sierra Club	Defends natural resources and wild places. The nation's largest and most effective grassroots environmental movement.
Fishing industry (Salmon)	Wild salmon fishing in Bristol Bay, near the proposed Pebble Mine construction site.
Elders from a nearby village	Indigenous Leaders. The mine would impede on the traditional way of life for many of the Indigenous people in the area.
Transportation and construction of housing for mine workers (build port)	Building a mine would also increase the building of infrastructure surrounding the mine. This would lead to greater accessibility into the region and the price of goods would decrease for the local villages/people.
Moose and Salmon population	From the perspective of the animals. They will give their perspective and be part of the debate but not participate in the vote.
Local townspeople	Local area feelings about the mine. In 2006, one poll reported 28% of Alaskans in favor of and 53% opposed to Pebble and another reported 45% of Alaskans in favor and 31% in opposition.
Local business owners	Create significant revenue and create well-paying jobs

Manager of local EPA office	Will chair the debate.

Simulated Environmental Protection Agency (EPA) Meeting

Each participant had one minute to present their perspective. After all perspectives were presented, each participant then had one minute to refute any other perspectives or arguments. Then, after the presentations and debate, all the participants voted for the approval or rejection of the Pebble Mine project.

To explore other points of view, we then had the participants switch with another participants' viewpoint. From their new point of view, the participants were asked to research and present their new perspective at another EPA meeting. After this second round of presentations and debate, all the participants voted for the approval or rejection of the Pebble Mine project.

After the PSTs participated in both debates, they worked in groups to design their own role-play simulations involving local, environmental dilemmas from their communities. The simulations were designed to be implemented in their future classrooms, from kindergarten to grade six.

Data Collection

After the completion of the role-play activity, PSTs reflected on their experiences. PSTs responded to these prompts:
What were your initial thoughts BEFORE beginning the simulation?
What were your thoughts after your research on your assigned person about whether there should be mining?
What were your thoughts AFTER our simulated town hall meeting ("debate")?

Data Analysis

All student reflections were read and coded into categories. Investigators used thematic analysis to examine the data. The following codes were used for the first round of analysis:
Scientific knowledge helped in making informed decisions.
Environmental consciousness.
Recognizing multiple perspectives.
Role-playing and simulation-engaging strategy to teach the concept.
Connections to the world.
Others.

These six categories were further examined to identify the major themes as discussed in the findings section.

IV. Findings

While analyzing the reflections from the thirty-eight PSTs, major themes emerged from the reflections. These themes included scientific knowledge helping in making informed decisions, environmental consciousness, recognizing multiple perspectives, role-playing and simulation as engaging teaching strategies, connection to a real-world issue an engaging strategy to teach a concept, and others.

In our analysis of the reflections, we identified key themes that arose from the reflections. In this section, we describe student reflections and in-depth analysis in clusters. Most students acknowledged that scientific knowledge helped in making informed decisions on the role they were playing during the simulation activity. Some PSTs were neutral coming into this activity but changed their stance after engaging in this activity. One PST said: "Before we started research, I didn't really know what my side would be. I didn't know what the environment would take damage by if the mine was to be created. After gaining research, I realized the mine would affect the water which would affect our salmon."

On the other hand, the scientific knowledge gained by some PSTs confirmed the stance they had prior to doing any research. For example, one PST said: "Prior to conducting any research, I believed that the mining project should not happen due to the potential

environmental impacts of it. However, after doing research I found that environmental impacts were not the only reason I do not support the mine."

And another PST also said: "My beliefs were confirmed after the debate as well while hearing multiple perspectives, and facts throughout the debate also confirmed that it would not be beneficial to start mining. This debate helped me reiterate the idea of always making sure we research well on topics like this, so we know how to conduct strong, educated, opinions."

Others had initial beliefs that remained unchanged, for example, this PST reported: "I personally did not agree with the project and while that did not change after conducting the research, it did open my eyes to understanding the importance of gathering the facts for both sides of a topic."

And another said: "My stance on the mine did not change after doing the research, but I actually felt stronger in my stance. As humans, I feel that we do not think about the animals' perspectives in a lot of situations. While researching, I also learned a lot about the health risks for not only animals but also humans."

Throughout their reflections, the PSTs indicated some degree of environmental consciousness within their decision-making process as well as their love for environmental conservation. For instance, one PST said: "After reading about the salmon population and how their habitat would be destroyed, I am more certain in my decision that they should not continue to mine and destroy habitats."

Furthermore, some PSTs demonstrated their environmental consciousness from what they learned from this activity to conserve the environment. We read comments such as the following: "After researching my own perspective on preserving the natural land of Alaska and not developing the Pebble Mine, I stand by my initial thoughts of not developing the mine because it appears that it will do more bad than good for the environment and the economy." And another PST commented: "Even with all the evidence of helping the environment, I would still have voted no because it was taking away so much space and many animals' habitats."

One aspect that most PSTs brought forth was the recognition of multiple perspectives during this activity. The multiple perspectives they identified as being brought into the discussion were from subject matter and personal beliefs. These reflections were primarily seen in the reflections from the PSTs' response to the prompt: "What were your thoughts AFTER our simulated town hall meeting (debate)?" These reflections included appreciation of other people's perspectives as well as learning new knowledge from a new point of view. Thus, one PST said: "Participating helped me see others' points of view that I did not see yet, it did not change my mind. There were things that I did not agree with." On a similar note, another PST pointed out that this activity gave a picture of different perspectives in decision-making. She said: "This activity made me see that there are multiple perspectives that are brought together to vote. I agreed with my perspective, but I think it would be hard if I was assigned a perspective that I didn't agree with."

Even those who did not change their thoughts and perspectives after the activity still appreciated other PSTs' perspectives. For instance, one PST said: "My thoughts after the debate remained the same, however, I realized that there were valid arguments on each side of the debate. I realized that it is important to be open-minded and be able to listen to others who have differing opinions." Also, another PST said: "I am still for the mining of Pebble Bay. But I could relate to the elders and small fisheries that are against it. It is a tough decision, one that could be a mistake either way."

In addition to learning to appreciate multiple perspectives, the PSTs also learned to listen to divergent opinions, even if they didn't agree with the others' views. One student noted: "After the simulated town hall meeting, I viewed the issue as more multifaceted than I was exposed to in my research. I think this is a good example of how the information and sources we expose ourselves to have a strong influence on how we form our opinions." And another student reflected: "Once you put yourself in other people's shoes and see their

perspectives, it can have an effect on you… You may not agree with the views, but you are able to understand where they may be coming from."

The PSTs addressed the pedagogical aspects of the activity in the reflections. The PSTs involved in the activity were in their third year of the Elementary and Literacy Education program. Therefore, they had previous experience and knowledge that enabled them to more easily identify the pedagogy while being involved in the pedagogy. The two pedagogical aspects that emerged as most engaging were (1) the role-playing and the town hall simulation that was (2) related to a real-world environmental issue.

Here are comments from several PSTs about the engaging role-play and town hall meeting: "This can be a really fun activity to act out certain roles and host a mock town hall meeting. This is a great idea for a lesson that could last a few days!" And: "Researching and understanding unbiased facts is an important thing for us as citizens and for our students to learn, so I think this project was a great way to support this idea."

Other PSTs commented about the engagement in a real-world environmental issue:

"One thing that I really enjoyed about this activity was the authenticity of it. It was easy to get captivated in the debate and feel like it was real."

"Especially when it has happened in my own town, the research made me think of the things I never really have reflected or thought about while it was going on."

"When the debate was over, I felt as though I had learned so much about the mining dilemma. I think that this would be a great activity for my future students and can help every participant learn a lot."

PSTs also made connections on how they apply these pedagogical moves in their future classrooms as shown in the quotes below:

"I think this activity will be really beneficial in the classroom when teaching students about current events and social issues as well as learning how to conduct educated research."

"These types of pf inquiry projects allow students to have a voice in their learning and take the reins, while the teacher acts as the facilitator. This is such a rich form of learning for students, and I would love to incorporate this assignment into my future classroom."

In our close analysis from the PSTs reflections as discussed above, we can summarize that the main themes were a) Use of scientific knowledge to make decisions affecting self and society, b) Recognition of multiple perspectives, c) Environmental consciousness, d) Role-playing and simulation as an engaging strategy, e) Real-world connection and classroom application. The comments about application to their future classroom were unexpected by the investigators, but this confirms how powerful the use of role-play simulation is as a teaching strategy.

V. Conclusion

In developing this activity, we wanted to determine how role-playing encouraged our PSTs to develop multiple perspectives when faced with an environmental issue. When asked to reflect on the experience, one of the main reflections from our PST's was knowledge gained of the importance of understanding multiple perspectives when approaching an environmental issue. This supports the idea that by the PSTs engaging in dilemma and debate, they can learn to listen to divergent perspectives and engage with their peers on multiple perspectives surrounding an environmental issue as Sherrin (2015) states that role-playing cultivates empathy as students try to understand the perspectives and experiences of others. Recognizing that there are multiple opinions and being open to the ideas of others was reflected on throughout this activity. Students didn't often reflect on their personal ideas being changed, however they did reflect on understanding the importance of hearing other opinions and ideas and, by participating in the debate, they could understand the environmental issue from multiple perspectives.

One of the unexpected findings from this activity was the impact of pedagogy on our PST's. The PST's involved in this activity were in their third year of the Elementary and Literacy Education program in their science methods course they could easily pick the pedagogy while involved in the pedagogy. We explicitly discussed the pedagogy involved

while participating in the activity and the impact of this can be seen in the PST's reflections of the importance of real-world application and role-play simulation increasing class engagement. Students reflected on how they could use role-play in their future classrooms and on how their future students could learn about environmental issues through this pedagogy. This supports the idea that science teacher educators should use more student-centered teaching approaches so that pre-service science teachers can experience the approaches themselves (Cetin-Dindar, 2022). Additionally, inquiry-based laboratory activities should be increased so that pre-service science teachers can follow their educators as role models and their teaching self-efficacy beliefs can be increased via vicarious experiences.

By engaging the preservice elementary teachers in scientific inquiry projects related to the real world in science content courses, the teacher candidates would have multiple opportunities to develop their understanding of science and scientific inquiry and, therefore, would be more likely to develop more positive attitudes toward science and become more confident and effective in teaching inquiry-oriented science to their future students (Liang & Richardson, 2009). By completing an activity designed with good pedagogy, the teacher candidates can see the method modeled and the benefits of using the pedagogical approach. As we found in our study, the teacher candidates can see the benefit of using this approach and communicate desire and confidence to use it in their own classrooms in the future. The pedagogical experience provided to them during their undergraduate education may result in them viewing themselves as practically good teachers. Additionally, as Neuendorf and O'Connell (2011) describe the value of role-plays in teacher education: "Pedagogically sound scenario-based role-plays are activities with a specific learning outcome designed to create a real learning experience for participants" (p. 2182). By modeling how to create a pedagogically sound scenario-based role-play, our PST's reflected on the benefits of being involved in a role-play and reflected on the desire to implement this type of pedagogy in their future classroom.

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