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Effectiveness of a Professional Development Program for High-School Science Teachers Using Avatar Role-Playing

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Abstract –

In this study, a professional development program for Japanese high-school physics teachers using avatar role-playing was developed and tested. A scenario for avatar role-playing was developed for the topic of Newton's third law of motion. Our avatar session was implemented 9 times for 9 in-service or pre-service teachers to see how each of the teachers teaches avatar students in a ten-minute lesson using active-learning type of instructional strategies. The sessions were video-taped and analysed using a set of observation rubric that includes three scales to measure the effectiveness of the teaching: 1) strategic skill scores, 2) active-learning type teaching scores, and 3) conceptual level scores. The results indicated that there are three common problems in their teaching. First one was the lack of focus in the process of developing student understanding. Second problem was the insufficient skills for incorporating student ideas in the process of conceptual building in the whole class discussions. Third problem was the insufficient questioning techniques for developing students' correct understanding of the scientific concept. The results also indicated that these problems were related to teachers' beliefs about teaching. Implications of the findings for the usefulness of the use of avatar role-playing in teacher education and connections to lesson study are further discussed.

Keywords: Avatar role-playing, high-school physics, professional development, active learning

1 Introduction

In this rapidly changing and unpredictable society, the education communities are expected to set their goals to raise citizens who would be able to face the problems in the real world as their own and find the best solutions for the problems by collaborating with other people (MEXT, 2014). Especially in the fields of science and technology, the burden that every citizen has is heavy as each one of them has to make their own decision for issues that would require scientific knowledge to understand. A good example may be a decision on the car they drive: should it

be a gasoline car or an electric car? Under such circumstances, it is important for students to develop abilities to find best solutions for scientific problems through inquiry-based science learning.

The national curriculum standards, called Course of Study in Japan, were fully implemented in high schools in 2022 (MEXT, 2018), and inquiry becomes as the centre of science education in high schools as well as in elementary and middle schools. Also, the importance of so-called "student-centred, collaborative, and deep approach to learning" or "active learning (AL)" is emphasized in high schools. However, it is said that high-school lessons are implemented mostly by one-way transmission of information (MEXT, 2017).

There have been numerous active-learning approaches implemented through lesson study in Japanese lessons in elementary and middles schools. However, in high schools, lesson study is rare and it is difficult for a high-school teacher alone to change the culture of one-way transmission of knowledge prevailing in the community. In addition, the difficulty and the overwhelming amount of content that has to be covered in class for preparing for college entrance examinations puts the hurdle for teachers to change anything in their teaching even higher. Japanese research on lesson improvement in physics are mostly focused on developing teaching materials. Little opportunities are available to learn actual use of AL-type instructional strategies in Japan. Many high-school physics teachers have hard time acquiring the skills for implementing AL-type instructional strategies. How can we help them acquire such skills? More practice-based approaches than lesson study for improving high-school physics lessons are needed.

On the other hand, the use of avatar role-playing in education has been around since early 2000s in the United States. Recently in Education Department at University of West Florida, they developed an online program called "Teach-To-Avatar" (UWF, 2021) under the pandemic. The program uses avatar role-playing for pre-service teachers in STEM fields to help them acquire questioning skills and skills for promoting student discussions. They use computer software by a company called Mursion. In the avatar session, a pre-service teacher teaches a short science lesson to avatar students as part of their teacher education program. They also combined lectures and other activities with the avatar sessions to make it a whole program for pre-service teachers to take. The researchers at UWF reported that pre-service teachers' skills improved.

In this study, the overall goal is to develop a professional development (PD) program for in-service high-school physics teachers in Japan that uses avatar role-playing and to test its effectiveness for promoting AL-type instructional strategies in real lessons. In this paper, however, the discussion is focused on identifying teachers' pedagogical issues using avatar role-playing as the first step toward developing a PD program. The research question that guides the study presented in this paper is "How the use of avatar role-playing is effective to identify high-school physics teachers' pedagogical issues?"

2 Methodology

A professional development session using avatar role-playing for in-service physics teachers was developed by a group of researchers. A scenario for the topic of Newton's third law of

motion was developed. The focus of the scenario was on AL-type instructional strategies and student-centredness in order to identify teachers' pedagogical issues. Software by a company called Mursion was also used through a Japanese agency. Figure 1 shows a scene of a virtual classroom where avatar students are sitting while a teacher is teaching Newton's third law of motion from an actual classroom using two carts for a demonstration and blackboard behind him.

Ten-minute avatar role-playing sessions were conducted for 3 in-service and 6 pre-service teachers. The participants were selected by using a convenient sampling technique from different places in Japan. The sessions were video-taped, and video data were collected and analysed in February to March in 2022.

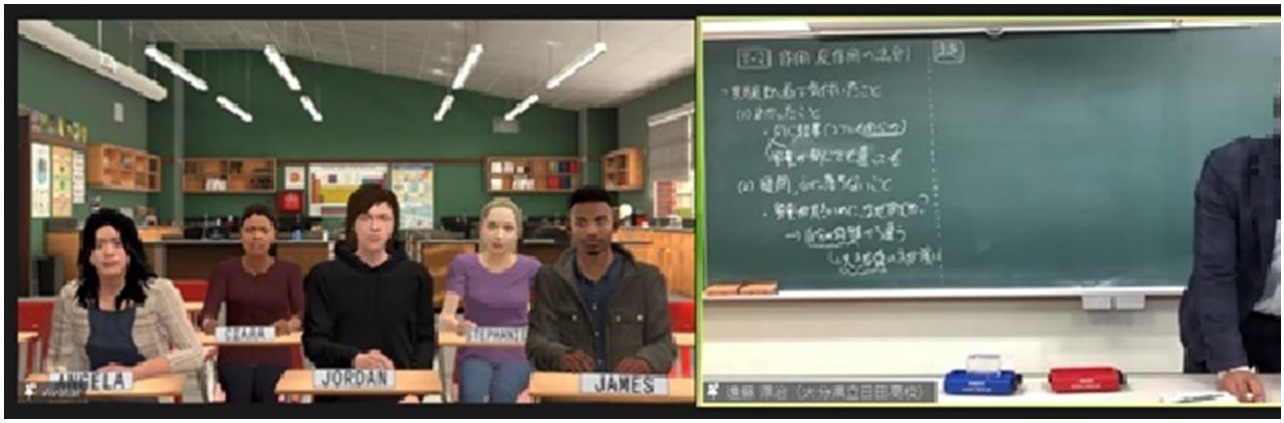

Fig. 1. A scene of the avatar role-playing session

For the analyses, an assessment method for identifying teachers' pedagogical issues towards AL-type teaching was developed. Three scales were created. First one was strategic skill scores. Ten instructional strategies that promote student active learning were identified through literature review (see Table 1), and scores are given for the number of items observed in the session.

Table 1. Items for strategic skills

	Item		Item
1	Let students explain the meaning	**6**	Encourage to use diagrams, drawings, modeling, equations, etc.
2	Repeat, rephrase, or reinforce student answer	**7**	Encourage to connect with prior learning and experiences
3	Encourage students to speak up, such as "It's Ok to make a mistake."	**8**	Encourage to give examples
4	Wait for student answer	**9**	Encourage to think from multiple perspectives
5	Encourage student-student talk	**10**	Praise students and agree with students

Second one was AL-type teaching scores. Five items are selected from Reformed Teaching Observation Protocol (RTOP) by Sawada and others (2000). Five items for AL-type teaching

scores are shown in Table 2. Scores are given in the scale of 1 to 3: 1) teacher-centred, 2) teacher-centred with incorporation of student discussion, and 3) student-centred.

Table 2. Items for AL-type teaching scores

	Item
1	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.
2	Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.
3	Students were involved in the communication of their ideas to others using a variety of means and media.
4	The teacher's questions triggered divergent modes of thinking.
5	The metaphor "teacher as listener" was very characteristic of this classroom

Third one was conceptual level scores. Three levels were identified based on the correctness and focus of content knowledge that the participants have shown in the avatar sessions. Three levels were indicated in the second column of Table 3.

Strategic skill scores and AL-type teaching scores are combined into 3 levels of pedagogical content knowledge (PCK). Based on the level of content knowledge and PCK, 9 levels for teaching were identified as indicated in Table 3. The number of teachers in each of the levels is shown in the far-right column of Table 3.

Table 3. Levels for teaching

Level	**Content Knowledge**	**PCK**	**N=9**
11	Insufficient understanding of the physics content/focal point	Teacher-centred	2
12		Teacher-centred, but student discussions included	2
13		Student-centred, support student own way of understanding	0
21	Sufficient understanding of the physics content, but the focal point is not clear	Teacher-centred	0
22		Teacher-centred, but student discussions included	4
23		Student-centred, support student own way of understanding	0
31	Deep understanding of the physics content, clear focal point, coherent order of presenting the content	Teacher-centred	1
32		Teacher-centred, but student discussions included	0
33		Student-centred, support student own way of understanding	0

From Table 3, you can see only one participant was at the 3rd level of content knowledge. It can be also seen that none of the participants showed fully student-centred approaches.

3 Findings/Results and Discussion

The fact that only one teacher was at the 3rd level of content knowledge means the lack of conceptual focus in many of their physics lessons. Also, the fact that none of the teachers was at the 3rd level of PCK means the lack of student-centredness in their teaching. Many teachers did not use students' ideas to develop the scientific concept they wanted to teach. In addition, questioning techniques to trigger student thinking were observed to be insufficient. Teachers were not persistent in helping students express their ideas using questions. Based on these results, three pedagogical issues common to teachers were identified: 1) insufficient questioning skills, 2) lack of conceptual focus, and 3) insufficient development of the lessons with student ideas.

4 Conclusion

In conclusion, three common pedagogical issues were identified, and we found that avatar role-play is shown to be effective in revealing teachers' pedagogical issues.

A program is now needed to be developed to overcome the identified issues. Through the participation in this role-playing session, many of the teachers themselves found the weakness of their teaching. Research is underway to include watching experts' session and discussing with peer teachers in the program to help them develop and refine their instructional strategies. Also, it would be great if teachers are able to use avatar role-playing more freely on their own so that they can practice their teaching skills over and over again. To make such practice sessions available, more inexpensive ways to use avatar role-playing needs to be developed. Currently, a researcher in computer science was invited into this research and he is working to develop our own software program for avatar role-playing.

In the future, this avatar role-playing can be combined with lesson study. Lesson study can be used to try teachers' new pedagogical skills acquired through avatar sessions. Or, when issues are identified through lesson study, avatar sessions can provide practise for teachers to overcome the issues. It would be very interesting if we can find new ways to use lesson study together with avatar role-playing.

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