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Innovating Pre-service Science Teachers' Professional Development with Virtual Reality

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Abstract: As the need for authentic experiences has increased in the science education for 21st century learners, there has been more attention placed on the modes of instruction that can supply greater realism and immersion. In this light, the use of virtual reality (VR) has received considerable attention. I aim to conduct design-based research on novel approaches that support the professional development of pre-service science teachers based upon learning theories. I will also conduct experimental studies and case studies in order to have more in-depth investigation of the roles of VR and pedagogical scaffolds on improving the effectiveness of the professional development. Ethnographic or case studies will also be conducted to have a more comprehensive understanding of the pre-service science teachers' attitudes, perceptions, challenges, and expectations with regard to the VR integrated professional development method.

Keywords: VR, pre-service science teacher, learning theories, professional development

1. Introduction

Due to the implementation of the Next Generation Science Standards (NGSS), there has been an increased focus on the use of technology-integrated learning in the science classroom (Corrigan, 2015). This focus has put forward high demands on science teachers' capabilities of understanding the complexity of student learning, applying innovative technologies, and using of various instructional approaches (Howard, 2016; Lamb & Etopio, 2020). However, a lot of current professional development programs for science teachers are built around strict standards that would make it difficult for trainees to have personalized guidance they need (Lamb & Etopio, 2019). A lack of practice in real world situations is another limitation (Lamb & Etopio, 2020).

One possible solution is to integrate the Virtual Reality (VR) technology into professional development for pre-service science teachers. VR has been believed to have considerable potential for science learning and teacher preparation (Tondeur et al., 2017). Integrating VR exposures to science classroom could assist in the learning of real world experiences (Starr et al., 2019). Additionally, with the support of VR, pre-service teachers could have opportunities to confirm, extend, or disconfirm their knowledge about how they would react in classroom (Lamb & Etopio, 2020).

However, current research on applying VR in teachers' professional development typically focuses on creating a simulated class for trainees to perform augmented and active teaching practice. VR's affordance of improving the understanding of complex scientific knowledge and phenomena was ignored. Additionally, learner theories have not been considered to guide the development of VR environment, especially for pre-service teachers' professional development. Most studies evaluated the learning and training outcomes only based upon usability-oriented tests. I see them as limitations.

2. Research Agenda

I intend to conduct designed-based research to design a VR integrated professional development method for pre-service science teachers which could not only provide opportunities for pre-service teachers' instructional practice, but also facilitate their understanding of scientific knowledge and effective science teaching strategies. This innovative VR integrated, learning theories based professional development method could not only provide opportunities for pre-service teachers' instructional

practice, but also facilitate their understanding of scientific knowledge and effective science teaching strategies. They could also have teaching practice in the virtual class with the scaffolds designed based upon learning theories. Moreover, the pre-service teachers are guided to design their own VR integrated teaching units, and teach with VR in the simulated class under the supervision of their instructors and peers. In the design-based research's iteration process of designing, implementing, and revising, the final designs of the professional development, together with the scaffolds, will be achieved.

My prospective effort on the innovative professional development method for pre-service science teachers is to have in-depth investigation on its effectiveness. Experimental studies will be conducted to compare pre-service teachers' learning achievement, professional skills, and teaching performance under the conditions with different scaffolds. Current research on the evaluation of the effectiveness of teachers' professional development mainly focuses on one-time assessment of trainees' real-life outcomes, such as the teaching performance, the knowledge of pedagogical theories and science content, or the usability-oriented tests. However, the process in which the trainees' professional skills develop and their understandings of teaching and learning change is ignored. There is a recent trend in the educational technology research that researchers exhibit a greater interest in participants' neuropsychological and neurocognitive process, which are viewed to objectively reflect participants' learning process, and directly affect their real-world outcomes. Based on this trend, I intend to further analyze the pre-service science teachers' neuropsychological and neurocognitive reactions in the professional development. Data will be collected in the form of the participants' hemodynamic responses and neurocognitive processing via the 3D body sensory technology and a SensoMotoric Instrument (SMI) Scene Eye Tracker. These data will unpack the pre-service science teachers' cognitive, motivational, and meta-cognitive conditions and changes during the professional development.

I intend to carry out ethnographic studies or case studies on pre-service science teachers' attitudes, perceptions, and the reactions with regard to the VR integrated professional development. These studies aim to unpack its impact on pre-service science teachers' professional development based upon their own experiences. These empirical studies are not only for the proof-of-concept of the findings of the experimental research, but also for informing the pedagogical practice and the designs of the VR integrated professional development with the ultimate aim of nurturing a culture of personalized and active learning. That would help to have a more comprehensive insight into the process of pre-service science teachers' professional development, their challenges, expectations, and effort on meeting the increasing demands of 21st learners, and their perceived useful support to enhance their professional development in a technology-rich environment.

3. Significance of Research

This research will also shed an insight into the scholarship of teaching and learning, especially in helping teacher educators to identify ways to increase the effectiveness and efficiency of pre-service science teachers' professional development with the support of innovative technologies, such as VR. It is deemed timely in the transformation age of education.

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Developing STEM teachers' TPACK skills through scaffold co-designing activities

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Abstract: This study is to explore whether and how to scaffold co-designing activities between teacher-researcher collaborations in STEM inquiry-based project can transform teacher's TPACK-related skills. In this study the scaffolding focus on those can external represent students' learning process, such as collaborative concept mapping tool, thinking mapping tool or argumentative diagram tool. Some recruited STEM teachers will designing and implementing domain-appropriate and skills-building scaffolds in STEM instruction with the guidance of researchers in learning science. During the whole co-design and implemented process, the discourse data, reflective notes data, classroom video data, TPACK questionnaire data and interview data will be collected and analyzed. The study can provide some insight for teacher professional development, but also can lay foundation for the design of learning environment for teacher's profession development.

Keywords: co-design, scaffolding, Design-Based Implementation Research, TPACK

1. Introduction

STEM education includes problem-based learning that purposefully situates scientific inquiry and the application of mathematics in the context of technological designing/problem solving (Sanders, 2009). Therefore, to promote the effect of STEM education for learners, teacher should equip TPACK-related skills to handle STEM education. However, STEM teachers faced many constraints. Many teachers lacked sufficient professional knowledge or skills about STEM education because they had no enough prior relevant professional or instructional experiences in their practices (Nesmith & Cooper, 2018). On the other hand, positive outcomes of STEM education can only be achieved when teachers integrated scaffoldings to structure the complex learning processes (Kaendler, Wiedmann, Rummel, & Spada, 2015). Instead, teachers often provided students minimal guidance during STEM instruction (Kirschner, Sweller, & Clark, 2006). Considered that little research has been devoted to identifying the supports that teachers need to teach about complex systems in the classroom (Yoon et al., 2017). The study aims to find a way to help teachers in designing and implementing domain-appropriate and skills-building scaffoldings in STEM instruction. It will not only elevate the competences of STEM teachers, but also elevate the quality of STEM education.

2. Theoretical background

Co-design is the kind of work between teachers and researchers to design, implement and evaluate innovative educational experiences to fill local educational needs and also gain some valuable opportunities to reflect and refine their instructional practice (Matuk, Gerard, Lim-Breitbart, & Linn, 2016). Nowadays co-design of innovative learning environments serve as contexts and catalysts for teacher professional development, which can lead to teacher agency, and flexible, adaptive, principled pedagogy (Wong, Gao, Chai, & Chin, 2011). Based on the notion of learning by design, when teachers engaged in design process with the help of researchers, it can help them make intimate connections among content, pedagogy and technology in a collaborative way (Agyei & Voogt, 2012). Moreover, according to social construction theory, co-design between researchers and teachers is a kind of social interaction. It can help teacher gain fresh perspectives and advance both knowledge and action on instruction, but also can prompt them to rethink their practices, and explore, derive and pilot creative alternatives (McKenney, Kali, Markauskaite, & Voogt, 2015). In the context of design scaffoldings to

support STEM education, researcher had much theoretical knowledge of scaffoldings, which should be used to in STEM instruction. While, teachers may did not understand how to integrated scaffoldings in STEM instruction. Therefore, how to enable teacher design scaffoldings during STEM education by co-design is a promising way for professional development. The study intends to examine whether and how the method of co-design of scaffoldings between teacher-researcher collaborations in STEM problem-based project transform teacher's TPACK.

3. Methodology

Participants include teachers from a public middle school in Eastern China. The research team will work closely with the participating teachers to co-develop STEM curricula for a semester with four steps. In the first step, teacher was introduced to the background information of scaffolding. The next step is to co-design STEM education integrated with scaffoldings. In the third step, teacher will enact their lessons plan in their class. In the four step, teacher will communicate with each other with their reflection during the whole process. After each step, teacher will write reflective notes to recode what they learned and think. Besides, during the whole process, the research team will communicate with each teacher group and provide them some help timely according to their requirement. During the whole co-design and implemented process, the discourse data, reflective notes data, classroom video data, TPACK questionnaire data and interview data will be collected and analyzed.

4. Challenges and Questions

Some context and practical factors may bring some resistances with the collaboration between researchers and teachers. How to make researchers and teachers understanding each other is the tough issue to address. Moreover, different types of data will be collected. How to synthetical analysis those kinds of data to get understanding the development of STEM teachers' skill is very important. Thirdly, how to get some implication for large scale STEM professional development program show be considered more seriously.

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