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Teachers' Perception of IT in Science Education

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Abstract: In this paper, we report findings from a qualitative inquiry into teachers' perceptions and experiences of using IT, specifically simulations in science education. Semi-structured interviews were conducted with 12 science teachers. Thematic analysis reveals that teachers' perception towards simulation use in science teaching included three aspects: (a) perceived affordance of teaching with simulation in the science classroom, (b) perceived affordance of learning with simulation in the science classroom, and (c) perceived affordance of simulation infrastructure in the science classroom. With the attitudes described above, most teachers mainly had the experience of adopting simulation for demonstration purpose in a teacher-led instruction. Attempts to let students operate simulation themselves and explore alternative modelling did not seem to work well, considering the inadequate school facilities and limited classroom time to cover the required syllabus. Based on the findings, we propose the FLIPPING framework – using interactive simulation in flip learning approach. We believe the 8 key components in FLIPPING framework (Flexible environment, Learning culture, Intentional content, Professional educators, Preparedness for learning, Infrastructural readiness, Novice-proof interface, and Guided pragmatism) can alleviate both material difficulties of simulation implementation (e.g. infrastructure), and non-material challenges (e.g. student readiness) and promote the use of interactive simulation in science teaching in sustainable ways.

Keywords: Science Education, Teacher Perception, IT

1. Introduction

ICT, specially simulations, has been increasingly influential in science education because it can help students visualize abstract scientific concepts (McElhaney & Linn, 2011; Wu & Huang, 2007). On one hand, by allowing students to visualize abstract concepts as well as to explore and test scientific modelling, computer simulations have been claimed to promote students' deep learning and conceptual understanding in science, such as optical lenses (Chang et al., 2008), moon phases, trajectory motion, relative motion (Monaghan & Clement, 1999), etc. In addition to greater achievement, computer simulations were also found to significantly enhance students' positive attitudes towards science subjects.

While a growing number of simulations have been developed, research has shown that simulation implementation in the science classroom is slow and challenging (Mehlinger & Powers, 2002; Pelgrum, 2001; Schwarz, Meyer, & Sharma, 2007, Schrum, 1999; Strudler & Wetzel, 1999). To solve those issues, most recent studies focused on increasing teacher training and developing pedagogical strategies to use interactive simulation in science classrooms (Khan, 2011; Kopcha, 2012; Schwarz & Gwekwerere, 2007). However, our early interactions with teachers indicated that the extent of simulation implementation still seemed to be quite low, despite the organized teacher training and developed pedagogical methods.

This paper reports a study to understand science teachers' perceptions and experiences of simulation implementation after workshop training. Individual interviews with different teachers from various schools across Singapore were the main source of data which were later triangulated with their lesson plans and students' assignments. The findings of the study will yield useful insights of the implementation process and will suggest an approach that could potentially support the implementation of interactive simulation in science education in sustainable ways.

Although it has been acknowledged that computer-based modelling using simulations can facilitate modelling-oriented instruction and students' deep learning of physics concepts (Goh, Wee, Yip, Toh, & Lye, 2013; Wee et al., 2012), research on how teachers can effectively integrate simulations into physics classes is rather scarce in Singapore. The present project is a professional development and research study that examines teachers' use of simulations after participating in hands-on workshops about the tools and related pedagogical approaches. This paper explores science (physics and chemistry) teachers' perceptions of teaching with simulations after their training workshops. We also aimed at understanding how their perceptions shaped their simulation implementation in classrooms, and what challenges do they face during the implementation process.

In total, 12 teachers from 7 schools across Singapore agreed to participate in the individual interviews. Among the 7 schools, 5 were government schools where students' proficiency levels varied and 2 were independent schools with high achieving students in Singapore.

2. Methodology

The goal of the present research was to explore science teachers' post-training perceptions towards simulation use in class, as well as their teaching practice when implementing simulation in science classroom. A qualitative study (Merriam, 1998) was adopted for this study as it allowed for exploring the phenomenon through the perspectives and experiences of the subjects in the study.

The primary method of data collection for the teachers' perspectives was individual semi-structured interviews. Among the 12 interviews, 11 were conducted face to face and 1 was via telephone. Semi-structured interview was conducted to allow for the variation in the question order as well as potentially additional questions and probes to particular individuals (Creswell, 2007).

Thematic analysis (Miles & Huberman, 1994) was used to abstract the data. Patterns within the data were developed and then categorized into codes and themes. To ensure the accuracy of interpretation in the qualitative data, other experienced scholars in qualitative research were invited to categorize themes based on the research questions and literature. Disparity in developing codes and themes was discussed until a complete agreement was reached. The consistent triangulation in the data analysis among various researchers prevented the potential risk that the interviews might be analysed only from one researcher's own subjective standpoint (Yin, 2013). From the process of thematic analysis, two major themes appeared, including teachers' perceptions of interactive simulation in science education (what they think after training), and teachers' past experiences of simulation implementation (what they did after training) in the classroom practices.

3. Findings

We present findings on teachers' perceptions of stimulation use in science teaching first, followed by their implementation experience in class.

3.1 Teachers' Perceptions towards IT in Science Teaching

Although teachers agreed on how simulation can enable students to visualize abstract concepts in an interactive way, they tended to demonstrate more concerns than favour. Their concerns included three major aspects: (a) perceived affordance of teaching with simulation in the science classroom, (b) perceived affordance of learning with simulation in the science classroom, and (c) perceived affordance of simulation infrastructure in the science classroom.

Simulations afford visualization capacity for more abstract topics. All the 12 science teachers considered interactive simulation to be useful only for instructing certain abstract topics, such as kinematics, dynamics, magnetism, etc. They all admitted the "innovative and fun part of technology in teaching", but the major advantage of simulation in science teaching seemed to be limited to the visualization of abstract concepts. Under such circumstances, teachers would consider using simulations in class based on the availability of resources provided as well as the match between the provided resources and their teaching plans of specific topics. Teachers with technical backgrounds in

ICT tools are also open to the customization of simulations while adopting them in teaching. Simulations do not afford benefits equally for all topics. More concrete and easily observed phenomena may be better introduced in a laboratory setting or even a traditional classroom, as described by interviewed teachers —either instead of or as a precursor to using simulations. When it comes to other topics, however, most teachers considered simulations to be redundant, especially when you have the option of demonstrating scientific concepts in real-life settings, either in classroom or laboratory. Furthermore, teachers find simulations are also limited to the more proficient students while using it in science teaching. Among the 12 interviewed teachers, 10 teachers demonstrated the concern of students being unable to catch up with the simulation in class. The exception though are the 2 teachers from the top schools in Singapore where students' proficiency level are among the highest in the country. According to the teachers' interviews, teaching with simulations seemed to confuse many of their students, especially the weaker ones. Therefore, they felt they had "no choice but to revert back to pen and paper".

After receiving trainings of interactive simulation and trying it in class, teachers discovered mixed effects on student learning. On one hand, it was consensus among the majority that students became much more engaged in learning when simulation was used to demonstrate abstract phenomenon in science. Different from the traditional approach when students would just sit down, listen to the teacher and look at the textbook, simulation was believed to be "a strong variation of learning approach", which was effective to link different topics as well as promote students' learning interest. On the other hand, some teachers noticed the complication simulations brought to learning in class, especially when the students were asked to operate the simulations themselves. This could be due to two major reasons: the need for extra learning of the software and potentially misleading representation in the simulation. In support of this statement, another teacher also from a government neighborhood school mentioned that most of the students from neighborhood schools are not the academically inclined students in Singapore, and "they might not be much appreciative of the new technology in learning", not to mention they need to learn extra just to use the technology. Notably, despite the learning engagement or learning complication simulation has brought to students, the teachers' biggest concern is about whether simulation will really benefit students' learning outcome, especially in examinations. One teacher pointed out that what the students finally need to do is a paper-pen test where is no simulation. Hence they prefer to continue with learning in traditional ways such as writing down and calculating, etc. Another teacher agreed and added that within the limited time for the students to learn, he tended to give up using simulation and maintained the conventional approach because "ultimately we still need to get them to be prepared for examinations".

Teachers identified a variety of challenges in school infrastructure which they thought constrained the implementation of simulation in science teaching. First and foremost, students do not always have individual access to computers when needed. So teachers in government neighborhood schools struggled to implement technology in class due to the shortage of school facilities to begin with. Internet bandwidth is another challenge that most government neighborhood schools encountered since interactive simulation required fast and stable network while school internet barely reached the requirement. Even though independent schools might have eliminated those two challenges in hardware, the limited materials in simulation software were still restricting the potential adoption in class, especially the materials matching the context of the Singapore science curriculum. Without overcoming the challenges both in hardware and software, teachers would often doubt the possibility to implement simulation in science class, even many of them might have realized the potential benefits simulation can bring to science teaching and learning.

3.2 Teachers' Experience of Using IT in Science Teaching

With the attitudes described above, most teachers mainly had the experience of adopting simulation for demonstration purpose in a teacher-led instruction. Attempts to let students operate simulation themselves and explore alternative modelling did not seem to work well, considering the inadequate school facilities and limited classroom time to cover the required syllabus.

According to self-report accounts during interviews of how the teachers attempted to use simulations in their teaching, 10 out of 12 teachers used direct instruction while adopting simulation in their classes. The implementation was mainly for demonstrating scientific concepts without involving student interaction. They explained that they had limited classroom time to complete the school syllabus and prepare students for their final exams and so they could not afford to make the class more student-centered and provide opportunities for their students to operate the simulations themselves in class. Some teachers reported designing inquiry-based instructions occasionally in computer labs after they have completed the required syllabus. However, only the more proficient students seemed to be engaged while the less proficient students found difficulty catching up and hence lost interest in the lesson. As Teacher 11 described, the less proficient students in her class had no idea what the aim of the inquiry-based activity was, and they would always tend to look for answers, asking "what exactly do you want me to look out for? What do I have to do? Can you tell me what to do?" As a result, the lesson became more teacher-centered employed direction instruction in the end. In contrast however, the two teachers from the top schools used inquiry-based instructions a lot more while implementing interactive simulation in class. Admittedly, students were expecting more teacher guidance in such activities, but no obvious difficulty was indicated when they were asked to use the simulations and explored the alternative modelling under minimal teacher guidance. It was obvious that in most of the schools where students' proficiency level was average, both the teachers and students preferred direct instruction while using simulations in class. This enabled the teachers not only to fulfil their teaching duties within limited classroom time but also to ensure efficient students' knowledge acquisition and exam preparation. In contrast, teachers in the top schools were more willing to adopt inquiry-based instruction which their students were able to follow.

All the teachers attempted to integrate simulation in science teaching and learning after class, either as a required homework or an optional exploration for students to use simulation in their spare time. In this way, teachers felt they "did not have to distribute the limited classroom time to the use of simulation", and students were also enabled to explore the alternative modelling at their own pace. Notably, students were found to be responsive to learning with simulation after class only when it was required as homework, and tended to ignore the exercises when it was optional. Furthermore, certain amount of teacher guidance was also needed when students conducted self-learning after class as they needed help with not only the content knowledge of the subject, but also the technological knowledge to operate the software. As can be seen, teachers in our study seemed to embrace simulation use after class especially to promote the inquiry-based learning among students at different proficiency levels. The use of simulations after class also eased the facility shortage in school since students would have more places and platforms to use simulation in their spare time.

4. Conclusion

The findings in this study suggest that despite teacher training and technical support, the implementation of interaction simulation was perceived to be difficult among science teachers in Singapore context. Although certain teachers attempted to use simulation in their class, future intent to continue using was indicated to be low due to the limited classroom time to complete the required syllabus, and the pressing concern whether the use of interactive simulation can directly contribute to exam results. For some schools that were not well equipped with technological infrastructure, simulation implementation was impossible to begin with regardless of how positive teachers perceived the use of simulation in class.

Faced with the challenges both material (e.g. infrastructure, technical support) and non-material (e.g. teacher training) in implementing simulations in science education, most of the current literature focused on creating instructional models and strategies in classroom teaching (Khan, 2011; Schwarz & Gwekwerere, 2007). However, based on the findings of the present study we propose a more sustainable approach: flipping learning with interactive simulation. We extend the FLIP model (Hamdan, McKnight, McKnight, & Arfstrom, 2013) and FLIPPED model in higher education (Chen, Wang, & Chen, 2014) by proposing the FLIPPING framework with eight key components: Flexible environment, Learning culture, Intentional content, Professional educators, Preparedness for learning, Infrastructural readiness, Novice-proof interface, and Guided pragmatism. Informed by the present findings, this extension would better fit science education in Singapore context.

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