Using Technology to Support the Nature of Science in the Classroom

Aaron Heath
Te Rāngai Ako me te Hauora - College of Education, Health and Human Development, University of Canterbury, New Zealand

Abstract

The purpose of this literature review is to investigate how technology can be used to encourage the presence of the nature of science in a science classroom. Within the concept of the nature of science there is a strong focus on scientific inquiry which is the basis of a lot of the literature, but other aspects of the nature of science, such as providing meaning to content outside of the classroom are also covered. The promotion of the nature of science in a science classroom is a popular topic within the science education community, as student engagement and interest in the school subject continues to steadily decrease. The reviewed literature took a range of views into consideration to outline the beneficial links between the use of technology and having the presence of the nature of science in a science classroom. This review also discusses issues of economical and functional access to technology as well as the importance of correct implementation within a science education context.

Keywords: *Scientific Inquiry, Nature of Science, Technology in Science, Science Education.*

Introduction

The nature of science is commonly referred to as the why of science education (Gallagher, 1991; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). The essence of the nature of science is to provide opportunities for students to independently investigate scientific concepts and to see the subject as a socially valuable knowledge system (Ministry of Education [MOE], 2007). Students learn how scientific ideas are communicated and how they are linked to everyday situations. Despite a drive from governmental forces to include it in policy documents (MOE, 2007), there is still a disparity between legislation and classroom practice. In the last two decades, there has been a significant shift with regard to how science is taught in classrooms and how students perceive and relate to the subject. Previously, science teachers were regarded as the more knowledgeable other in all instances and the student was always considered to be the learner. These categorisations were very strict until recently when the ideas of scientific inquiry and the nature of science became more prevalent in curricula discourses (Sheffield, Dobozy, Gibson, Mullaney, & Campbell, 2015).

In trying to promote the nature of science, the scientific community have developed many tools, such as teaching as inquiry projects and the integration of local communities with curricula. One of the most successful facilitators of this promotion is the efficient and effective use of technology in the classroom (Goh, Chai & Tsai, 2013; Williams, Nguyen, & Mangan, 2017). With the ever-growing presence and impact of digital technologies in children's lives outside of the school context there has been a global push for education systems to adapt to this changing context. Many schools in developed countries are now transitioning towards modern learning environments and adopting a *Bring Your Own Device* policy. Digital technology provides countless opportunities for students to further their learning and engagement in any subject, if the technology is used responsibly and in the correct manner; science is no different (Guzey, & Roehrig, 2009). As student interest in the subject continues to dwindle, the integration of technology is helpful for promoting the values that the nature of science upholds.

Effect on Scientific Inquiry

One of the main ideas behind the nature of science is scientific investigation and inquiry, because it allows students to pose and find the answers to inquisitive questions which are not related to curriculum content. Technology is a key facilitator of this process as it empowers students to gain deeper understanding than the prescribed right answer (Williams et al., 2017).

Teacher Belief in Student Agency

Williams et al. (2017) focused their two-year case study on developing the skills of an in-service teacher with minimal technology or scientific inquiry background. One of the main points which came from this study was the effect that the teacher's attitude had on the effectiveness of the implementation of technology in the inquiry process. The teacher's beliefs were a critical factor for effecting change in their pedagogy and their role in the classroom. The participant in the study mentioned that if he believed in the students' ability to work independently, then technology provides a reassurance to teachers as they relinquish control of the students' learning. This was supported by the research conducted by Karamustafaoğlu, Çakır, and Celep (2015), which found that those teachers with a positive attitude towards the inclusion of technology were generally considered to have an expert and delegator teaching style. Karamustafaoğlu et al. (2015) argued that these attitudes correlated with a teacher who is confident in their own content knowledge and in the student's ability to expand their own. This is instead of a formal authority teaching style which is linked to the more traditional idea surrounding concrete teacher and learner roles by a transmission of facts. The research done by Dana, Zembal-Saul, Munford, Tsur & Friedrichsen (2001) also aligns with this argument, as they concluded that one of the main reasons why the inclusion of technology is minimal is because of teacher personality.

Access to Information

One of the more obvious benefits to technology within the scientific inquiry process is the ability to access information that would have been previously unavailable, such as online databases and research journals. The case study run by Sheffield et al (2015) focused on teacher education students and the importance placed on Technological Pedagogical and Content Knowledge (TPACK). The study showed that the confidence of pre-service teachers to integrate technology in inquiry increased dramatically when information communication technology (ICT) was deliberately integrated into their own teacher education programme. The intentional exposure meant that teachers were more aware of the multiple avenues to access and present information and were more likely to promote the use of databases, and the like, within their own classes. In the year-long study undertaken by Guzey and Roehrig (2009) they reiterated to the participants (in-service teachers) that the National Science Education Standards in America encourage the use of a variety of technologies to make the most of the vast quantities of valuable information which young scientists now have access to. Sheffield et al. (2015) state that the extensive access to information online allows the articulation of a problem, the examination and shaping of a problem, researching, and finally presenting a solution. Going through this process is typical for an inquiry process and allows learners to ask those inquisitive questions which endorse the idea of the nature of science in a classroom.

Opportunity to Collaborate

Technology adds an extra dimension to collaboration in a classroom, because now class discussions are not restricted to the physical walls of the class or the timing of the lessons (Dana et al., 2001). With the ability to communicate online, with the right guidance, a community of learners can productively engage with one another at any time, on any topic. Many students may be technologically literate in some respects, for example social media, but they may struggle to use technological tools to enhance their scientific inquiry. Creating an online community of learners allows students to enhance their ability to use technology in a way which engages them with topics that interest them. Even if those topics are not always directly linked to the science curriculum, the discussions would undoubtedly uphold the values of the nature of science as students strive for further understanding. Goh et al. (2013) undertook a knowledge building approach to teaching in a school in Singapore instead of the traditional transmission of facts. They found that knowledge building integrated with technology was effective in supporting interactive learning activities and enhancing social dynamics within a class. In this study, Goh et al. (2013) used a knowledge forum as the mediating technology to collaboratively improve the students' ideas as well as synthesising group knowledge. Being able to collaborate successfully with fellow students is a key pillar of the nature of science within many science education documents and the New Zealand curriculum (MOE, 2007) is no exception.

Relevance to the Real World

Technology has the potential to help students make links between their studies and understandings to problems and situations outside of both the classroom and the prescribed curriculum. For instance, technology can be used to simulate an experiment that would otherwise have been impossible to observe (Dana et al., 2001). Traditional limitations, due to access of supplies or safety concerns, can sometimes prevent students from connecting with a full range of knowledges. Dana et al. (2001) outlined how the use of technology allows control of one parameter at a time, which might not be possible in real time. One of the main foci of the nature of science is being able to relate the content of the curriculum to real world problems and life outside of the classroom. The case studies of four in-service science teachers by Guzey and Roehrig (2009) showed how over time, the teachers moved away from being the permanent more knowledgeable other. The incorporation of technology into their practice meant that the students could research aspects of the curriculum from a multitude of avenues. As each student related the learning to facets of their own lives, it opened the possibility to co-construct knowledge as the teacher takes on the learner role. Williams et al. (2017) mentioned that technology allows the student to take responsibility for their own learning as they find answers to their own questions. Their two- year study showed the progression of the teacher and the students, as their respective roles within the classroom became less distinguishable. As the students became more intrigued by how they could use technology to relate content to the real world, the knowledge within the classroom became increasingly co-constructed.

Ching, Joyce and Chin-Chung (2013) reviewed many case studies of the effective implementation of TPACK into general education. Almost all of research that was taken into consideration yielded positive results in enhancing teachers' ability to integrate ICT into their practice. From the perspective of the students, the results suggest that the effective use of ICT in any subject provides opportunities for the student to relate problems to the real world. Ching et al. (2013) go on to mention how these opportunities to find meaning in content on a personal level are a key building block in engaging and maintaining student interest. The knowledge building approach which Goh et al. (2013) undertook, brought to light that many students have misinformed views of the nature of science, such as how it can be related to curriculum content Their research found that if these views are left unchecked, this may impair the student's ability to appreciate the role science plays in societal progress. In comparing their results to a control group, they also stated that technologies help students to find science interesting, comprehensible, and relevant to daily life. The teacher in the Williams et al. (2017) case study raised an interesting point that the answers that technology can help us find are not always straightforward or what one might expect. When one of his students brought this up in class, the teacher replied saying that sometimes life does not always reveal answers how we might perceive them and that it takes time and effort to make meaning from new knowledge. This was an interesting link to be made between the use of technology in a scientific inquiry and the real world, which supports the main values upheld by the nature of science.

Barriers to Successful Implementation

There are many barriers to the successful implementation of technology in science which the literature alluded to through quantitative and qualitative research. When undergoing a scientific inquiry, the technology is typically used as a tool to assist with the students' ability to research, collaborate, and present their information. The case study conducted by Williams et al. (2017) demonstrated that if the ability to use the technology is hindered, such as unreliability with a school network, then very unsuccessful and unproductive lessons can occur. Williams et al. (2017) went on to say that this unreliability meant students were forced to use personal devices such as cellphones, which slowed down the inquiry process immensely because students became more distracted. Following on from this idea of access is the fact that some schools and communities do not have the economic support to provide technology to students or to their children (Maeng, Mulvey, Smetana, & Bell, 2013). Some classrooms are a single computer environment, which is a huge potential barrier to trying to include technology in a whole class inquiry.

While investigating the attitudes of teachers towards technology, Karamustafaoğlu et al. (2015) found that even though very few teachers would dispute the benefits that technology can provide to education, their own beliefs would hinder them from effectively integrating technology into their practice. This was not necessarily a characteristic of age, but generally those teachers who had been in the teaching profession for longer were less likely to willingly learn how to successfully use technology as a learning tool. This finding was elaborated on further by the research done by Maeng et al. (2013) as they analysed pre-service teachers TPACK knowledge in comparison to in-service teachers. The lack of familiarity with content knowledge and pedagogical approaches of in-service teachers is one of the main reasons why there is a lack of inclusion of processes such as inquiry and the use of technology to facilitate this. This point was also covered by Dana et al. (2001), when they identified one of the main challenges to effective implementation of technology was the ongoing challenge of teaching TPACK effectively to teachers. They go on to say it is not only a challenge to teach TPACK correctly but to reach as many in-service teachers as possible, so there is not a divide in TPACK knowledge between pre-service and in-service teachers. Dana et al. (2001) emphasise the importance of preparing new teachers for facilitating the change to happen from within the school, because the lack of training of current teachers continues to be a hindrance.

The values of the nature of science can sometimes be perceived as very time consuming (Osborne et al., 2003; Goh et al., 2013) and classes (especially those undergoing National Certificate of Educational Achievement (NCEA) are already extremely pressured to include all the necessary content for the required assessments. Even though the use of technology has been proven to open and diversify the scientific inquiry process its use means that time becomes more of an issue (Dana et al., 2001). Maeng et al. (2013) alluded to this in their study as teachers expressed their frustration with the current emphasis on preparing students for standardised assessments.

Future Implications

Reflection, by students, teachers and teacher educators, both individually and with peers, allows the refinement of information technology supported inquiry practices (Williams et al, 2017) and the values of the nature of science to be clearly identifiable in a science classroom. Karamustafaoğlu et al. (2015) argued at the end of the results of their case studies that science teachers should continually reflect on their practice if they are to continue to improve their practice. They also found that those teachers who reflected frequently were more aware and open to trying varying teaching styles and resources (Karamustafaoğlu et al., 2015). Guzey and Roehrig (2009) said that the varying degrees of development the teachers showed with regard to their understanding and inclusion of TPACK, was in part to do with the degree of reflection taking place. The teacher's pedagogical reasoning affected their own ability to enact in their classrooms what they had learnt from their educator programmes. Ching et al. (2013) analysed 225 critical reflections of in-service teachers where they found that only 13% of these teachers were facilitating students learning *with* technology as opposed to from technology. If science teachers become more aware of their pedagogies and teaching styles, while also reflecting on literature, then features of the nature of science will find their way into the science classroom. Once a teacher can acknowledge the importance of the nature of science, then the use of technology is a natural facilitator for lecturing, demonstrating, and inquiry (Maeng et al., 2013). One of the teacher reflections from the Maeng et al. (2013) case studies said, "science and technology are increasingly intertwined, and this relationship is a natural one to foster".

Conclusion

The purpose of this literature review was to analyse how technology can affect the presence of the nature of science in a science classroom with a number of factors being identified. One of the key aspects of the nature of science is scientific inquiry and the ability of learners to ask and to engage with curious questions that they are interested in. Technology allows learners to ask these questions of personal interest, as it provides avenues for them to be answered. Many case studies recorded the benefits of technology in facilitating collaboration both with peers and the community, as an online community or forum base was incorporated into the inquiry. With the effective and responsible use of technology there are also excellent opportunities for the student to express agency. Under the guidance of a teacher, technological tools allow students to research, collaborate, and present their inquiry in a more individualised manner. Another main pillar of the nature of science is finding meaning to curriculum content and then linking these new understandings to real world situations and societal problems. Technology has the ability to control experimental parameters which might not be possible within a science classroom context, allowing explicit examples to be drawn upon. While analysing the literature a number of barriers to the successful implementation of technology were recognised. These included but were not limited to: time constraints associated with such a task when preparing students for assessments, the economic issue associated with ensuring all students have equal access to technology, and the lack of TPACK that current in-service teachers possess. In terms of future implications, this review focused on one particular aspect which was reflection. This needs to be on behalf of the students, pre-service, in-service, and teacher educators to ensure that everything is being done to incorporate the values of the nature of science into the science classroom, and in many cases, this will be aided by technological tools.

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