

Connecting with pre-service teachers' perspectives on the use of digital technologies and social media to teach socially relevant science

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As an interdisciplinary team of educational researchers we explored pre-service science teachers' perspectives on using digital technologies and social media to address socially relevant issues in science teaching. The rationale for teaching socially relevant science was embedded in the concept of renaissance, thus underscoring the need for science to be perceived as a human activity. We drew on generational theory to consider the educational significance of digital technologies and social media. Two different activities were used to elicit the pre-service science teachers' perspectives. First, we invited them to reflect on a digital animation that we had produced, and they highlighted the advantages of digital animation as a medium to communicate a socially relevant message more appealingly to the Millennial generation. We then engaged these pre-service teachers in a structured concept-mapping activity to consider how digital technologies and social media might be used to address social challenges in South Africa. They drew our attention to the affordances of digital technologies and social media as a means to facilitate critical thinking, cater for diverse learning styles, and make high-quality scientific knowledge more accessible. They highlighted that teaching socially relevant science using digital resources can be cheap, convenient, collaborative, and creative.

Keywords: digital resources, generational theory, science teacher education, socio-scientific approach, technologies for change

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Introduction and research background

The recent Framework for Institutional Quality Enhancement from the South African Council on Higher Education (CHE) identifies key imperatives for change in South African higher education. One of these is the imperative to address national needs, such as social justice and economic development, through higher education. Another is to equip students for the 21st century by facilitating critical and creative engagement with increasingly ubiquitous social media and digital technologies (CHE, 2014).

Our research team consists of five teacher educators from diverse disciplinary backgrounds in the School of Education at a South African university. Although we teach in the separate specialisations of Gender and Education, Languages and Arts, Mathematics Education, Science Education, and Teacher Development Studies, we share an interest in addressing pressing social issues and engaging with new technologies in higher education curricula. In this article we consider how the two national imperatives for change mentioned above might interconnect in the teaching of science education.

This article builds on our previous research exploring the use of digital technologies, in particular, digital animation, as an innovative and responsive method for integrating social issues in higher education curricula. We created and screened a digital animation entitled *Take a risk: It's as easy as ABC*, with the aim of provoking discussion and interaction among university educators on integration of social issues in higher education teaching and learning (Pithouse-Morgan et al., 2015). For the research reported on here we extended the opportunity for response to the same digital animation to a group of pre-service science teachers and sought to answer the following question: What are pre-service science teachers' perspectives on the use of digital technologies and social media to teach socially relevant science? We did this in two stages: first, we invited the pre-service teachers to use a temporary Internet link to find, view, and critique the animation, and second, we engaged the pre-service teachers in a concept-mapping task to elicit their perspectives on the use of digital technologies and social media to teach socially relevant issues in science.

This article begins with a brief explanation of our research focus on socially relevant issues in science education. Next we draw on generational theory (Codrington & Grant-Marshall, 2004) to consider the educational significance of digital technologies and social media. Thereafter, we describe the process of working with the pre-service science teachers to elicit their perspectives on how addressing pressing social issues and engaging with new technologies might interconnect in the teaching of science. We go on to examine the pre-service teachers' responses to the digital animation as well as their viewpoints as expressed through the concept-mapping activity. To conclude, we consider what we as teacher educators and educational researchers can learn from the pre-service teachers' insights into the potential value of using digital technologies in teaching socially relevant science.

Teaching socially relevant science

Unprecedented and pervasive global environmental challenges (for example, climate change) have resulted in a reconsideration of the role of education in general and of science education in particular (Onwu & Kyle, 2011). The rationale for a re-thinking of science education, which Mudaly refers to as a renaissance, calls for science teachers to perceive science as a human activity, and requires the adoption of a “socio-cultural approach to science education” (Mudaly, 2011: 29) instead of seeing science as “something that exists in human minds as concepts, skills and representations” (Roth & Lee, 2003: 264). From this perspective the imperative of science education is to provide young people with a greater sense of environmental consciousness and to foster a “moral obligation to the planet” (Hart, 2007: 689). Lemke (2001) contends that in re-envisioning a science education which is socially relevant, the focus of science education should be embedded in the ubiquitous political and cultural issues that influence people at that point in time.

A re-thinking of the focus of science education is inextricably linked to re-thinking teacher education in relation to science. A focus on the teaching and learning of pre-service teachers in general and in science in particular, is essential if universities are to respond to national and global challenges, and thus deliver a socially relevant education. In order for pre-service teachers to engage with the notion of a socially relevant science education, they need to think deeply and reflect critically on the relationship between the teaching of science on the one hand, and society on the other.

Using generational theory to consider the educational significance of digital technologies and social media

Codrington underscores two conceptual pillars of generational theory. The first pillar is the “socialization hypothesis”, that proposes that values inculcated during childhood are carried into adulthood and remain relatively stable throughout one’s life. The second is the “social constructivist theory” (2011: 2), which suggests that an individual’s world view develops through social interactions.

Generational theory “does not claim to be able to either explain the individual actions of individuals, or to be able to predict an individual’s behaviour” (Codrington, 2011: 20) and there are “no hard and fast rules about, if, and where people fit into the generations” (Codrington & Grant-Marshall, 2004: 69). However, as Codrington points out,

Generational theory states that people born at a similar time in history, experiencing similar political, social and economic realities, educated in similar systems with similar curricula, and influenced by similar popular culture will develop similar worldviews. (2011: 2)

Most generations, according to Codrington (2011), do not have specific start and end dates, but there are generational categories and years of birth that are generally

accepted. These categories and birth years are: GI (born 1900s-1920s); Silent/Traditionalist (1920s-1945); Baby Boomer (BB) (1946-early 1960s); Generation X (Xers) (late 1960s-1980s); and Generation Y/Millennial (1990s-2000s). Codrington and Grant-Marshall (2004) adapted these years of birth for the South African context; because of particular historical and political events in South Africa, the dates are delayed by approximately seven years.

In our study the generations that are of interest are the BBs, Xers and Millennials, because we (teacher educator-researchers) may be classified as BBs or Xers. We identify ourselves as educators who were “not born into the digital world but have, at some later point in our lives, become fascinated by and adopted many or most aspects of new technology” (Prensky, 2001a: 2) and we see it as a vital part of our work to develop curricular activities that can assist critical and creative interaction with new technologies.

The pre-service teachers who participated in this study fall within the Millennial category. According to Codrington one of the defining characteristics that makes generations different is “new technology” (2011: 4) developed during the particular generational category. In South Africa, for example, the sharing of cultures from other countries was made possible through the introduction of television in 1976. Television influenced the lives of BBs because prior to the 1970s and this technological development South Africans were relatively isolated from cultural experiences in other countries. Similarly, the development of technology during the Xer generation has made “Techno-literacy” (Codrington, 2011: 4) one of the defining and guiding values of Xers.

In contrast to the technological context in which the BBs and Xers grew up, the Millennials are accustomed to a social environment in which there has been an explosion of “new forms of communication, greater connectedness, personalised and portable media” (Codrington, 2011: 7). For the Millennials, television as well as other forms of digital technologies and social media are no longer considered new technologies. Defining and guiding values of the Millennial generational category are being techno-savvy and having social and cultural experiences amid media and entertainment overload. According to Maürtin-Cairncross, the following are some traits of Millennials.

... they are globally aware and globally connected; they value diversity, collaboration and achievement; technology seems to be a natural part of their lives; they have a strong sense of civic duty; they have a highly developed ability to multi-task; and they are energetic ... (2014: 565).

Furthermore, Codrington (2011) suggests that the Millennial generation includes young people raised in an era marked by the heightened fragility of the social, economic, and natural environment, and who consequently might have a greater awareness of ethical responsibilities.

Researchers such as Klopfer, Osterweil, Groff and Haas (2009) contend that Millennials spend a great deal of time engaging with popular digital technologies and social media, including Facebook, My Space, World of Warcraft, and Sim City. Green and Hannon (2007) and Klopfer et al. conclude that digital technologies and social media are completely integrated into the lives of Millennials. Similarly, Dawley (2006) maintains that Millennials are highly familiar with digital interfaces, as well as the rules and language that enable interaction with digital technologies. Scholars such as Klopfer et al. (2009) and Cowie and Khoo (2014) observe that Millennials use social media and digital technologies to create, learn, and communicate new things in novel ways. They argue that the relationship that these young people have with knowledge generation and communication has been transformed through their use of digital technologies and social media, and that it is therefore essential for teachers to understand the pervasive influences of digital technologies.

However, scholars also raise concerns about possible assumptions underpinning motivations for the use of digital technologies in teaching and learning. For example, Otrell-Cass, Cowie and Khoo (2011) caution researchers about the notion that young people are necessarily “digital natives” (Prensky, 2001b: 1), arguing that learning spaces for young people need to be created to enable them to understand the affordances of digital technologies in education. Koseoglu (2013) adds that it is unwise to position teachers as “digital immigrants” (Prensky, 2001b: 1) in the land of students, and that careful consideration needs to be given to student preferences and skills related to the use of digital technologies in order to learn. Koseoglu (2013) advises that although many studies reveal that students have access to digital technologies and networks, context-specific research into student resources and preferences is required. Likewise, focusing on the South African higher education context, Maürtin-Cairncross cautions, “It is also important to note that although some students have embraced these technologies and tools of the Net Gen, this is by no means a universal experience, as there will be students who do not present with these characteristics” (2014: 578). Maürtin-Cairncross therefore recommends that South African higher education institutions conduct research into students’ experiences of, and perspectives on, engaging with new technologies in learning and teaching.

These insights made us mindful of two disparate considerations related to the pluralistic South African context. The first is that some of our students are probably not only digital media and technology experts, but also possess other traits and knowledge that we as BBs or Xers may lack. The second, which is based on our experiences of working with South African students from diverse socio-economic backgrounds, is that we should not assume that all our students are necessarily “native speakers of the digital language of computers, cellular phones and videogames” (Makoe, 2012: 92). We were aware that while rapid advancements in network technologies and digital devices have resulted in these becoming increasingly accessible (Koseoglu, 2013; Schuck, Aubusson, Kearney & Burden, 2012;

Songer, 2007) and schools in the Global North tend to be equipped with computers, wired and wireless communication, software applications and programs and Internet for teaching and learning (Songer, 2007), undergraduate students in South Africa often come to university from schools in which digital resources are severely limited or non-existent (Ndlovu & Lawrence, 2012).

Methods: Working with the pre-service science teachers to elicit their perspectives

The pre-service teacher [student] participants

A mixed-sex group of 79 third-year pre-service teachers between the ages of 20 and 24 years volunteered to participate in the study. These participants were registered for a Natural Science Method module that forms part of the Bachelor of Education programme. They were given information about this study a week prior to engaging in discussions about digital technologies and social media during a 90-minute science education lecture.

Small group discussions on the digital animation

Prior to the lecture we asked the pre-service teachers to view our digital animation, *Take a risk: It's as easy as ABC*, on YouTube. This animation is based on the issue of curriculum integration of HIV and AIDS as a critically socially relevant issue. As we explain in Pithouse-Morgan et al. (2015), we had previously screened this short video at three different locations to elicit responses from diverse groups of our peers (university educators). We then extended the opportunity to pre-service teachers to respond to the same digital animation.

At the start of the lecture we asked the pre-service teachers to form 17 groups of 4 or 5. We expected that their working in small groups would allow for more in-depth deliberations. To begin with, we asked each group to share and write down their reflections on the digital animation. The prompt for discussion was: Reflect on the use of digital animation to integrate HIV and AIDS in teaching. In this way we aimed to stimulate the participants' thinking about using digital means to initiate discussions about a socially relevant issue, such as HIV and AIDS integration, in a teaching context. This was a point of entry into a broader discussion about the use of digital technologies and social media to teach socially relevant science. These small group discussions on the digital animation were audio-recorded and transcribed, and used as the first data set for this study.

Concept-mapping on teaching of socially relevant science using digital technologies and social media

In preparation for the concept-mapping activity with the pre-service teachers we highlighted the potential value of critical pedagogy in science. We formulated the

following statement as part of the introductory information for the concept-mapping task.

Paulo Freire provided insights into critical pedagogy. Teaching to improve society is one of the aims of science education. In order to teach for social change, we need to think critically and understand social challenges. This task provides a platform to extend the work on critical pedagogy, by enabling you to reflect collaboratively on how digital technologies can be used to teach socially relevant science.

Next, we asked the groups to discuss their ideas about the teaching of socially relevant science using digital technologies and social media, and to record their ideas on a structured concept map (see Figure 1). We used the groups' concept maps as the second data set for this study. As Butler-Kisber and Poldma explain, "Concept mapping is a diagrammatic and visual means of expressing ideas held in the mind" (2010: 4). We anticipated that by creating concept maps through brainstorming and organising key words and phrases in a diagrammatic form, the groups of participants would be able to communicate their evolving ideas in an informal and non-linear way. We provided the following guidelines for the concept-mapping activity.

Brainstorm/hold a discussion about the following topic:

How can digital spaces, made possible by digital technology (cell phones, computers, software, tablets, digital video and audio recorders, etcetera) and social media (Twitter, Facebook, YouTube, WhatsApp, blogs), be used to address social issues, such as HIV and AIDS, malnutrition, or other, in science education?

- Decide on the social issue
- Decide on the digital technology
- Decide on the social medium
- Complete the concept map

The structured concept map template we developed used the image of three intersecting sets with a common intersection at the centre (see Figure 1). The common intersection represents the particular group's integrated curriculum space, in which thinking about the teaching of science takes place when they are using a selected medium and digital technology for their chosen socially relevant scientific issue.

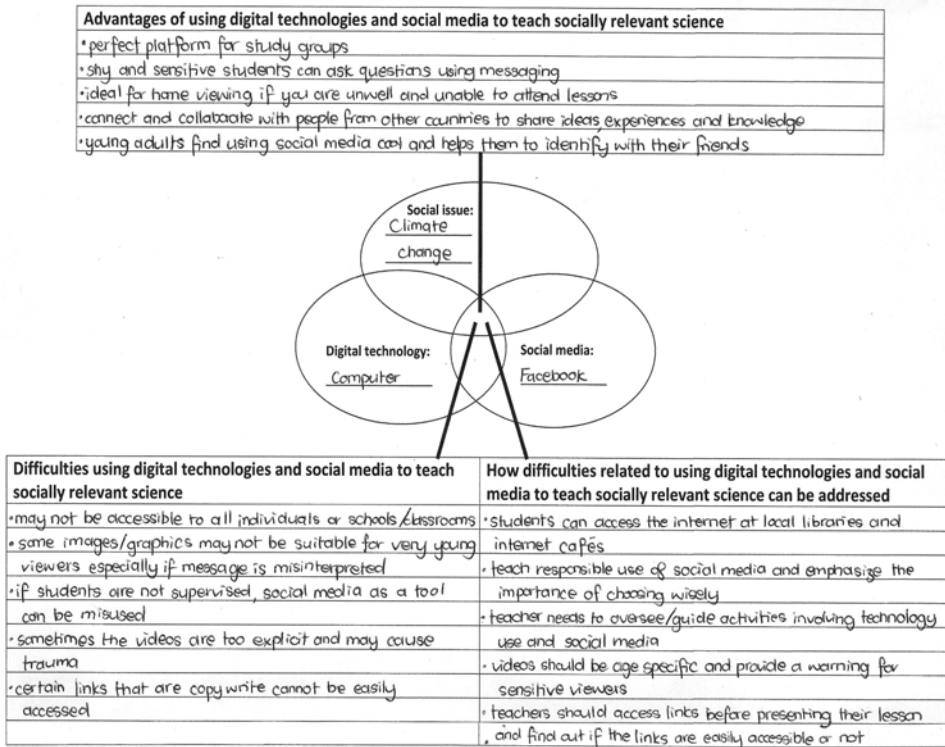


Figure 1: An example of one group's responses represented in the structured concept map.

Presentation and analysis of findings

The presentation and analysis of findings are presented in two parts. First, we present our findings and analysis of pre-service teachers' reflections on the digital animation that we produced. The second part is based on the concept-mapping activity that provides insight into participants' perspectives on digital technologies and social media for especially the teaching of socially relevant science.

Pre-service teachers' reflections on the digital animation

We discuss the pre-service teachers' reflections on the digital animation under two broad themes: the medium used to present the information in the digital animation; and the message conveyed by the digital animation (Pithouse-Morgan et al., forthcoming).

The medium

Several reflections related to the use of digital animation as a means of communicating about a social issue (in this case, HIV and AIDS), and these indicated that participants considered animation to be an effective medium for this. Several positive aspects

were highlighted by the participants, as well as several suggestions made for improvement.

Positive comments

Positive comments from the pre-service teachers' audio-recorded discussions about the animation included: "animation is fun"; "appropriate"; "appealing and attractive"; "creative and innovative"; "interesting"; "intrigues the viewer"; "conveys information to learners [that is] more learner centred" and "allows students to pay attention". More specific responses about the medium, such as "the characters were friendly and funny" and the "cartoon style made it suitable for any age group" suggest that some participants enjoyed the informal manner in which a serious social issue was presented in the animation that was "not too clustered [cluttered]" (see, for example, Figure 2).

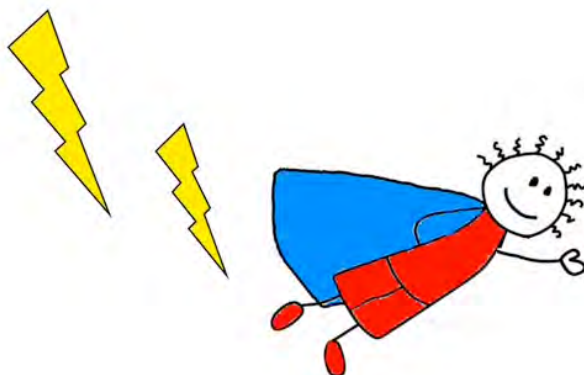


Figure 2: Screen shot from digital animation: Take a risk: It's as easy as ABC!

Suggestions for improvement

Some responses pinpointed particular aspects of the animation where improvements were considered necessary. This is evident in the following:

... the animation could have been better in terms of its drawing.

Voices could have been used for the [characters].

A better background song could have been chosen and more colour should have been used.

It is too quick, I could not read the information. It is confusing because of the format of the video in terms of questions and answers.

There are a lot of things to remember including the scenes and the characters.

The speech bubbles, the words are too long and they made me lose concentration

Audio could have been added to say what was written on the video in order to assist blind learners

These comments provided us with insights into how we might work with digital animation in a way that is more appealing to Millennials. Some of our participants found the animation to be text heavy (see, for example, Figure 3), and would have preferred shorter messages or audio messages rather than written text. Participants, in stating these should cater for people with visual impairments, also alerted us to the need for digital animations to be more inclusive. This suggestion is in keeping with the view that Millennials tend to have a heightened awareness of social issues (Codrington, 2011).

The suggestion to use more colours and improve on the background song draws attention to the need for us as BBs or Xers to be more familiar with the interests of Millennials when we are using digital animation as a teaching or research tool.



Figure 3: Screen shot from digital animation: *Take a risk: It's as easy as ABC!*

The message

While the pre-service teachers' reflections focused mostly on the medium of the digital animation, there were also some responses relating to the message. Most reflections from participants' audio-recorded discussions indicated that they felt that the message was suitably conveyed in the animation. For example, they pointed out that it was: "packed with useful information"; "focused and informative"; and

“relevant to us as future teachers”. In addition, they noted that the animation provided “different teaching strategies for effective learning”. Only one participant argued that the message lacked substance, by noting that the animation “[d]idn’t provide much information”.

From these responses we conclude that the message conveyed in the short digital animation not only provided relevant information but presented content in a dense, compact form. In addition, the animation successfully served as a prompt for further discussion. The responses indicate that the participants also considered a message presented in the form of a digital animation to be appropriate for use in pre-service teacher development.

Findings and discussion: Concept mapping

In this second part of the findings and analysis we consider the content of the concept maps produced by the groups of pre-service teachers. In their concept maps the 17 groups identified a range of issues and concerns. We tabulated each group’s responses according to the headings in the structured concept map and then examined responses to identify key notions. We highlight the key notions under each of the three main headings: (1) Socially relevant scientific issues; (2) Technologies for change; and (3) Advantages in using social media as a learning medium.

Socially relevant scientific issues

The groups of pre-service teachers identified a range of socially relevant scientific issues that could be addressed using digital technologies and social media:

- Health issues (tuberculosis (TB), HIV and AIDS, cancer, obesity, weight, and malnutrition);
- Social issues (abuse of women and children, and rape, substance abuse, poverty);
- Environmental issues (pollution, global warming, climate change).

The participants’ choices related to pressing social issues in contemporary South Africa. According to Statistics South Africa (2013) approximately 5.26 million South African people were living with HIV and AIDS by mid-2013. Also, from 2002 to 2009 the prevalence of TB among South Africans increased, and it is unlikely that the Millennium Development Goals for decreasing the spread of TB will be achieved (Republic of South Africa, n.d.). The continued high prevalence of HIV and AIDS and TB in particular in South Africa makes health a socially relevant issue and, through the concept-mapping activity, the pre-service teachers were encouraged to think about how they could use digital technologies and social media to teach about these topics.

Similarly, Statistics South Africa (2000) reported that the rape of women and children is often accompanied by physical violence such as the use of knives and guns, or by the threat of violence. Mathews et al. (2004), Jewkes (2002), Baldwin-Ragavan (2010) and Wood and Jewkes (2001) report on extremely high incidences of

violence against South African women and children. Social ills such as poverty and substance abuse are often linked to the abuse of women and children (Jewkes, 2002). The participants were mindful of these social ills and viewed them as relevant topics to be included in science education using the affordances of digital technologies and social media.

According to the National Climate Change Response White Paper (Government of the Republic of South Africa, 2011), South Africa is highly vulnerable to environmental challenges, especially the effects of climate change. This has resulted in vigorous debates about using education as a vehicle to make our society more resilient to climate change and other environmental challenges. The pre-service teachers viewed environmental issues that could be addressed using social media and digital technologies as socially relevant within the context of science education.

Technologies for change

The three digital technologies that the pre-service teachers recommended for addressing pressing social issues were cell phones, digital video cameras/recorders and laptops/computers. The social media spaces that they preferred were Facebook, YouTube, and WhatsApp.

The most commonly selected digital technology was cell phones (9 groups) and the most favoured social media space was Facebook (13 groups). According to SAinfo (2012), there are approximately 29 million cell phone users and approximately 6 million personal computers in South Africa. While this would suggest that approximately 60% of South Africans use cell phones, in reality cell phones are often shared, which extends access. In addition, in 2012 at least 7 million South Africans (approximately 14% of the South African population) had Internet access on their cell phones (Rao, 2012). This means that cell phones may be used to provide immediate, continuous access to social media spaces such as Facebook, YouTube, and WhatsApp. Social media spaces are becoming more popular with South African Internet users. Meier's (2013) research indicates that there are approximately 9.6 million Facebook users and 4.7 million YouTube users in South Africa. (No statistics related to WhatsApp South African users are made available by WhatsApp.)

Advantages in using social media as a learning medium

Through their concept maps the pre-service teachers expressed a variety of perspectives on the use of digital technologies and social media to teach socially relevant science. In making sense of these ideas through inductive analysis, we identified four key notions that we tagged using four terms that appeared frequently in the concept maps: "cheap", "convenient", "collaborative" and "creative", which we labelled 'the 4 Cs'.

Cheap

Participants perceived the use of digital technologies and social media to teach socially relevant science as an inexpensive form of communication.

It [social media] is easier to access, cheaper and it can also be accessed worldwide therefore it can reach a lot of people

WhatsApp is cheap, affordable and convenient.

The pre-service teachers' responses resonate with Makoe's observation that one of the reasons mobile technologies are appropriate in South African contexts is because cell phones are so "available, affordable and accessible" (2012: 92). Makoe's research at a South African university revealed that many students own cell phones that have Internet functions, so these students can readily make use of this form of digital technology for learning.

Convenient

The participants emphasised the ease of being able to access and interact with social issues in science through digital technologies and social media.

It is accessible and can be watched at our convenience which makes the process less tedious.

Not time consuming

Students' daily lives revolve around social media & therefore it is an advantage in gaining knowledge about social issues.

From these responses we can see that if a digital medium is convenient, accessible, and available, it might encourage an inductive approach to learning that could begin with a complex real-world problem in relation to which the students themselves generate facts, procedures, and guiding principles (Prince & Felder, 2006). From the participants' perspective it might be convenient and appropriate to use digital technologies to research real-world issues. If these facts could be gleaned during lectures using convenient, hands-on digital technologies to explore socially relevant issues, then fact-finding processes for learning could be promoted in science education and other disciplines. Furthermore, if the use of digital technologies is considered by pre-service science teachers themselves to be time-efficient, then fact-finding processes for learning about social issues may be adopted more readily in science education.

Collaborative

Pre-service teachers highlighted the potential for increased interaction and the participatory construction of knowledge.

It also allows for educators to connect and interact with learners. Learners who are timid in class can ask questions they need to ask or clarify content.

Encourages social constructivism because you can create group chats and post pictures informing people about proper diet, facts about obesity and how to live a healthy lifestyle.

Knowledge is constructed collaboratively and freely.

Connect and collaborate with people from other countries to share ideas, experiences and knowledge.

Hence, the participants drew attention to how technology can open up many new and exciting possibilities for collaboration among learners, pre-service teachers and others. For a Millennial generation of more techno-savvy students, opportunities for working together collaboratively as well as creatively are offered by the ever-increasing new ways of using media and communication (Prensky, 2005). In other words, through using technology and social media Millennials are able to integrate various functions of digital technologies as a natural part of their lives (Maürtin-Cairncross, 2014).

Creative

Pre-service teachers also pointed to the potential for innovation and enhanced enjoyment in teaching and learning. One group's response is illustrative.

Instead of rote-learning techniques, we as future teachers can use creative and innovative teaching methods to educate learners.

In particular, participants emphasised the power of visual modes for facilitating creative and participatory teaching and learning, offering comments such as the following:

It reinforces active participation of learners in class and also makes the lessons alive and enjoyable. Some learners may learn effectively by visualising instead of reading.

It makes it easier for the learners to understand what you talking about since they can listen and visualise at the same time.

The participants' responses align with findings by Otrell-Cass et al., who conducted an investigation to determine how digital technologies can be used to enhance the teaching of science, and found that student learning was supported specifically through "visual meaning making" (2011: 3). They found that by augmenting science lessons through the use of visual technologies such as digital animation, students were enabled to develop key scientific process skills, including representing results and justifying conclusions. In addition, they observed that students were stimulated to think independently and participate more actively in science lessons through the use of digital technologies.

Conclusion and implications

To conclude, we return to generational theory and to the strength of what we term the 4 Cs in digital research: they are cheap, convenient, collaborative, and creative. From a generational theory perspective, providing opportunities for pre-service

science teachers to reflect on, discuss and actively seek connections between digital technologies, social media and socially relevant issues made it possible for us as BBs or Xers to connect with and learn from our Millennial students. We noticed that the pre-service teachers were interested and keen to contribute to the reflections and discussions. This could mean that the pre-service teachers felt that they were able to provide worthwhile contributions to the group debates using their own perspectives on the use of digital technologies and social media in relation to socially relevant issues. The participants thus displayed social traits that are deemed characteristic of Millennials (Codrington, 2011; Maürtin-Cairncross, 2014).

Furthermore, from the participants' responses it was clear that they chose significant considerations to highlight during the *renaissance* mapping activity, focusing on specific topics that they deemed socially relevant in the South African science classroom. This suggests a possible shift in the way pre-service teachers are thinking about school science, and disrupts the conventional disciplinary rules about what science is, what topics are embraced in science education, the recipients for whom science education is intended, and the purpose of science education. Our participants moved in new directions, away from the hypothetico-deductive model of science, to a science embedded in social issues. More specifically, the fact that they stressed that using technology is cheap, convenient, collaborative, and creative appears to indicate that Millennials take cognisance of the social and economic environment in which they have been raised. Generational theory has been valuable in making sense of the data from the participants' responses, and to understand and plan our ongoing research into curriculum innovation at higher education institutions. In particular, generational theory drew our attention to the significance of responsiveness to the interests and characteristics of the Millennial generation by exploring and fashioning innovative teaching and learning.

As argued elsewhere (Mitchell & De Lange, 2013; Mitchell, De Lange, & Moletsane, in press), the ubiquity of cell phones in South Africa (increasingly cheap and convenient) suggests the potential for a pedagogical shift in knowledge production. We consider the 4 Cs to be of significance for classrooms in schools and universities in South Africa, with the potential for pedagogical transformation through increasingly easy access to digital technologies.

We might re-think the challenges of the various divides that are sometimes framed as digital but are simultaneously urban-rural, haves and have-nots, along with generational and racial divides. The participants clearly saw the affordances of digital technologies and social media as a way to reduce barriers to accessing information, and underscored the advantage of this technology as a means to facilitate socially relevant thinking in the science classroom. They provided insight into the potential of using technology in the science classroom to cater for diverse learning styles, and eradicate the notion that high-quality scientific knowledge is meant for, and can only be accessed by, the rich, educated, and elite.

The competence of these pre-service teachers with the digital, along with their optimism and enthusiasm, calls for a rethinking of what it means to teach and what it means to do research in South Africa.

Note

The concept *renaissance* is a term coined by Mudaly (2011). It is theoretically embedded within a socio-cultural perspective. It brings to the centre the need for science education to be viewed as a human activity, and advances the argument that the epistemology and methodology which govern science education are influenced by the dominant cultural, social, and political discourses during a particular period in time.

Acknowledgment

The digital animation was created through i-movie software 2Animate!. The stick figures come from stick figure clip art (<http://stickfigureclipart.com/peoplestickfigure>). We are grateful for the assistance of Melissa Driemeyer in creating the digital animation.

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