Learning and Teaching in the 21st Century: Realities and Possibilities of Social Media

The objectives of this international collaboration are to: a) study students' and teachers' use of social media for learning science across age groups and contexts, b) develop a model for understanding science learning through social media, and c) make recommendations for the use of social media as new and innovative tools for instructional practice in secondary and post-secondary science and science teacher education. A complexity thinking perspective (Davis & Sumara, 2006) was used to interpret student focus group data for the extent to which students embrace the interactive potential of social media to facilitate "unprecedented opportunities and affordances for emergent learning" (Williams, Karousou, & Mackness, 2011, Knowledge Ecologies, para. 4). Results indicated that students and teachers used social media, but not in ways that significantly improved the in-school and out-of-school learning environments. Focus group data informed the design of a survey of science student social media use which will be used to get a broad sampling of how students use social media to support their science learning and to identify cases for in depth study. Future work will examine student learning in case study contexts of social media use in science classrooms.

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Introduction

The purpose of this study was to explore the area of social media use in science teaching and learning. Social media are defined as software and web-based technologies that facilitate interactive dialogues and connectivity using the capabilities of Web 2.0 technology that allow for the creation and exchange of user generated content (Kaplan & Haenlein, 2010). Examples include video sharing platforms (e.g., YouTube), image sharing sites (e.g., Flickr), and social networking sites (e.g., Facebook, Twitter). In order to consider the multiple facets, interactive possibilities, and complexities of social media for learning and teaching, the study employed a complexity thinking perspective (Davis & Sumara, 2006) to design the study and to interpret data. The specific objectives of our international collaboration are to:

1) study students' and teachers' use of social media for learning across age groups (secondary and post secondary) and contexts,
2) develop a model for understanding science learning through social media,
3) make recommendations for the use of social media as new and innovative tools for instructional practice in secondary and post-secondary science.

The project is an international collaboration between researchers in Canada, Australia and Sweden across three contexts: disciplinary physics, high school science and science teacher education. The phenomenon of social media is both pervasive and world-wide, and our team-based approach aims to capture similarities and differences across and amongst our contexts in order to develop a model of using social media tools to learn science. As a preliminary study focus groups of high school and undergraduate physics students were conducted in British Columbia, Canada to explore how they used social media to support their science learning. This paper reports on the results of focus group data collection and how they will be used to design a survey of student social media use. In the next stage of the project the survey will be administered to students and instructors in a range of learning contexts at each research site. Survey data will inform the next stage of the project, which will focus on developing case studies. Case studies will be chosen to reflect the particularities and commonalities among the contexts.

Background: Social Media Practice

Historically the development of new technologies (language, mass production of books) has facilitated humans to cohere into grander unities with emergent behaviour (i.e., cultural groups). We adopt Bunge's (1999) perspective that technology defines a culture in terms of its methods, theories, and practices, in order to examine 21st century technologies such as social media. The general public's relationship with technology is still young—historically speaking—reaching back around 60 years while publicly funded education in Canada has been around for about 200 years. To put that in perspective, the evolution from mainframe computer to Apple iPad has occurred in a period shorter than the life expectancy of a child born this year in 189 of the 221 countries ranked in the Central Intelligence Agency (CIA) World Factbook (2012). Similarly, public education's relationship with technology is a relatively new phenomenon. It was not until the 1980s that technology began to gain a significant foothold in North American

education (Murdock, n.d.). Moreover, the last 10-15 years have seen significant technological changes with the rise of Web 2.0 and the participatory web, and new hardware emerging in the form of web-enabled, user-friendly mobile devices. A recent survey claimed that 35% of Canadians visit a social networking site everyday - a figure that was just 19% a year ago (Ipsos Reid, 2011). Of college students, 95% report using social networking sites, 70% of them on a daily basis (Smith, Salaway, Borreson, & Katz, 2009). Thus, these new technologies have become ubiquitous, connecting learners to each other and information, and may be leading to a major shift in how knowledge is created, stored, and shared.

Schools have found it difficult to keep pace. Educators are uniquely situated to scaffold their students to leverage the interdependencies of society and technology in a way that has yet to be fully explored. Educators are well positioned to guide students—our future citizens—in technology use, skill development, relating to and through technology, and in thinking about technology in complex, systematic, and socially responsible ways. Currently students are learning about technology from experience, not from education (boyd, 2010). Research has shown that learners rarely take advantage of the collaborative and creative potential of Web 2.0 technologies and that the application of these technologies for learning are strongly influenced by teachers and instructors (Bennett, Maton, & Kervin, 2008).

This paper describes the results of an exploratory study that used student focus group interviews to collet data about secondary and post secondary students' use of social media for science learning. The results were interpreted using a complexity thinking perspective, and conclusions and recommendations about how to develop effective practices for using social media for learning are offered. Background literature is provided around how youth and educators currently use social media.

Youth and Social Media

It has been suggested that a new generation of learners, 'digital natives', those born since 1980 and who have grown up in a digital world, will require a different kind of education system (Prensky, 2001a, 2001b, 2005) to prepare them for a workplace that has also fundamentally changed (Tapscott & Williams, 2006). More recently, Prensky (2009) has put forward the idea of digital wisdom and the notion that today's 'homo sapien digital' differs from today's human in that they are digitally wise in the way they access digital enhancements to complement innate

abilities and to facilitate wiser decision making. Schools have responded by incorporating a wide variety of technologies (e.g., Oblinger & Oblinger, 2005) to support learners who are also called 'new millennium learners'. For example, in British Columbia, the Ministry of Education recently released its Education Plan (2011) which "responds to the realities and demands of a world that has already changed dramatically and continues to change" (p. 2) through a focus on personalized learning, flexibility and choice, and learning empowered by technology. However, a recent literature review by Bennett et al. (2008) provided evidence that such claims are empirically and theoretically unfounded, thus opening the 'digital native debate' and establishing a need for further work in the field.

Some empirical evidence has recently been presented by Small and Vorgan (2008) regarding how use of digital technologies can affect neural pathways in the brain but empirical studies to better understand how students engage with digital technologies are needed. To explore the digital debate some large scale studies have been conducted in Australia (Kennedy, Krause, Judd, Churchward, & Gray, 2006), Canada (Bullen, Morgan, Belfer, & Qayyum, 2009), and the UK (Jones, Ramanau, Cross, & Healing, 2010). In the US, large scale studies include those of Ito et al. (2010), the National School Boards Association (2007), and include the work of the Pew Internet and American Life Project (ongoing).

Jones et al. (2010) conducted a survey of first year undergraduate students studying a range of subjects. They found that there were too many significant variations among students to justify the use of terms such as 'digital natives' to describe learners born since 1983. In his book, *The Young and the Digital,* Watkins (2009) used the results of an extensive study of teens' use of social media to paint a picture of how teens use, feel about, and experience technology. Through surveys, interviews, study of online spaces, and by closely following one four-pack of students for six months, Watkins (2009) was able to conclude that young people migrate to the digital world to "maintain and enliven their off-line relationships" (p. 23), not to connect with strangers online. For today's youth, time spent in front of a screen "is rarely, if ever, considered time spent alone" (Watkins, 2009, p. xix). Watkins' (2009) findings support earlier research by Ellison, Steinfield, and Lampe (2007) regarding undergraduate students' use of Facebook. Ellison et al. (2007) found that students reported "significantly more Facebook use involving people with whom they share an offline connection—either an existing friend, a classmate, someone living

near them, or someone they met socially…than use involving meeting new people" (Findings, para. 2).

A more recent study by Ito et al. (2010) found that the online social interactions of youth could be framed as either friendship driven, as reported by Watkins (2009) and Ellison et al. (2007), or interest-driven practices. Clark, Logan, Luckin, Mee, and Oliver (2009) conducted a study into the use of Web 2.0 technologies for learning at ages 11-16 in the UK. The study found that 79% of students used social networking and that 78% of students had shared artifacts (photographs, video, and/or music). Like Watkins' (2009) findings, Clark et al.'s (2009) results found that the primary motivation for using social networking sites was to interact with their existing social network. The vast majority of students said that they also used the Internet for study purposes, but the range of sites they used was limited. Few learners reported engaging in collaborative learning using Web 2.0 technologies, besides using instant messaging functions to 'chat' about school work.

These results are dismaying considering Lemke, Coughlin, Garcia, Reifsneider, and Baas's (2009) wide ranging survey of school administrators, superintendents, and technology and curriculum directors which concluded that "there is a growing body of evidence that the collaboration inherent in the participatory nature of Web 2.0 tools can be leveraged to deepen student learning through authentic, real-world learning" (p. 5). For example, Facebook's structure exemplifies "much of what we know to be good models of learning, in that they are collaborative and encourage an active participatory role for users" (Maloney, 2007, p. 26).

A 'Google Generation' study (CIBER, 2008) has shown that research behaviours such as impatience in search and navigation, and zero tolerance for any delay in satisfying their information needs, which were previously associated with younger ages, are now the norm for all age groups – young pupils to professors. However, given the overwhelming amount of information available on the Internet, most users tend to rely on guidance from specific people in their personal networks when searching for particular types of information (Kayahara & Wellman, 2007; Tepper, Hargittai, & Touve, 2007). Finally, another important finding is that for young people "experience with Web 2.0 technologies, particularly active engagement such as creation of blogs and wikis, tagging, meme-ing, reviewing, writing fan fiction, remain minority activities to which many learners are introduced by educators" (Beetham, McGill, & Littlejohn, 2009, p. 15). Similar results have been found for American undergraduate students where ninety

eight percent of students owned computers and 90% used social networking sites, but only 28% used social networking sites as part of their courses, and 25% had used wikis as a learning tool (Smith et al., 2009). Interestingly, students also reported only wanting a moderate amount of technology to be integrated into their courses (Smith et al., 2009). However, a study by Bullen et al. (2009) found that undergraduate students were not sophisticated in their use of technology but that they were sensitive to using appropriate technology in context. Student use of technology was driven by "factors such as the student and instructor dynamic within a course or program, the technical requirements of the discipline and the affordances that a tool provided within a given context" (Bullen et al., 2009, p. 10). Thus, research into how students use technology tools such as social media must begin to consider differential influence of discipline specific contexts. The current study being reported on focused on how students used technology for learning science in both high school and post secondary contexts.

Schools and Social Media

Schools have changed very little in comparison to the rapidly changing culture of technology, social communications, and the workplace (Davidson & Goldberg, 2010). Most of the work in the area of teaching and learning with social media has been conducted by researchers interested in e-learning and online learning (e.g., Franklin & van Harmelen, 2007; US Department of Education, 2010), but effective integration of social media into face-to-face learning contexts, including related policy creation, has been under-researched. Even in the online learning area, few rigorous effectiveness studies of K-12 online learning have been carried out (US Department of Education, 2010). Calls for paying more attention to how people move between online and face-to-face communication have been made (Attwell & Hughes, 2010). A recent report of two and four year colleges in the United States found that 80% of faculty use social media where 52% use them as teaching tools but are just beginning to realize the innovative, interactive, and collaborative possibilities (Bart, 2010). However, there is a growing community of teachers and professors who are integrating social media into their classroom practices.

Lemke et al. (2009) found that Web 2.0 technologies such as sharing visual media files, blogging and creating online collaborative projects were widely used in school districts and/or formal curricula. In 2009, edWeb.net, MCH Strategic Data, and MMS Education surveyed 1,284

educators (teachers, principals, and librarians) regarding their use of social networking and content-sharing tools. The researchers found that 61% had joined a social network and that these individuals participated "in more online activities than educators who had not joined a social network" (2009, p. 5). The research found that these educators were also "more positive about the value of this technology for education than those who haven't [joined social networking sites]" (edWeb.net et al., 2009, p. 5). Educators who used social networking did so for the personal desire to connect with family and friends, and for the professional desire to connect with colleagues and to stay current with the technology (edWeb.net et al., 2009). In context, the social media bans uncovered by Lemke et al. (2009) in 70% of US school districts make the lack of social networking use in the classrooms understandable.

EdWeb.net et al. (2009) found that "Social networks dedicated to education…have low penetration thus far, but there is growing awareness." (p.7). In fact, some respondents learned about sites such as Classroom 2.0, and edWeb.net from the survey instrument itself (edWeb.net et al., 2009). In "Final Report: A Survey of K-12 Educators on Social Networking and Content-Sharing Tools", the researchers found that "Although educators are joining social networks, they express a need for guidance, training, and professional development" and have expressed frustration with schools and districts that "often block access to sites" (edWeb.net et al., 2009, p. 8). The report went on to say, "Many educators recognize that they are behind the times in terms of technology, that their students communicate with these tools, and educators need to learn how to integrate social networking and content-sharing tools into teaching" (edWeb.net et al., 2009, p. 9). With regard to social media use by educators, the most heavily used social networking site by far was Facebook, with 85% of respondents reporting membership (edWeb.net et al., 2009). Significant memberships were also reported in MySpace (20%), LinkedIn (14%), and Ning (11%) (edWeb.net et al., 2009).

Currently, the Ministry of Education in British Columbia (Leadbeater, 2008), the Australian National Partnership Agreement on the Digital Education Revolution (Howard & Carceller, 2010), and the Australian Council of Deans of Science (Rice, Thomas, & O'Toole, 2009), have called for education reforms to implement 21st century learning including improved access to educational tools, and personalized learning curricula through the use of communication technology. Social media will play a key role in these education reforms;

however, more research is needed in order inform policy and to make recommendations about how education should respond to our increasingly connected culture.

While past research has created a foundation of literature with valid empirical results, work has not, so far, been undertaken with a theoretical perspective that offers any recognizable potential to shed light on *why* connectedness facilitated by social media may profoundly change the way people learn. Attending to the connectedness afforded by social media represents an opportunity for investigating the global trends toward increased social media use and its potential for learning in new ways.

Theoretical Perspective: Complexity Thinking

A powerful new theoretical perspective is emerging in educational research, complexity thinking (Davis & Sumara, 2006). Complexity thinking draws upon characteristics of self-organizing complex systems that exhibit intelligent behaviours without a centralized controller (e.g., ant colonies and crowds), to both understand and prompt learning. Social media have increased our awareness of the complex systems that are a part of our everyday lives. For example, the Internet is a decentralized network where many weak links and a few crucial nodes enable the swift searching capabilities of Google (Mitchell, 2009). Wikipedia is an emergent artifact of co-created knowledge where authorship is no longer a relevant concept. Each of these systems has learned (i.e., adapted) as a result of information shared through 'neighbour interactions' between many agents in the network. Psychologist Merlin Donald (2001) used the complexity of technology to infer stages of how human consciousness evolved and to explore implications for learning and teaching. It seems plausible that the ability to connect masses of human minds and store large amounts of digital information could lead to a new stage of consciousness (Davis, Sumara, & Luce-Kapler, 2008). Today's 21st century learners are plugged into this complex network of information through the connections enabled by social media, which may profoundly change the way they can and do learn.

Complexity thinking offers a transdisciplinary perspective that calls the researcher to pay attention to interactions across several levels of complexity – the learner, the classroom, the culture – i.e., policy and practice. Technologies such as social media are key to the structure and dynamics of each of these levels, possibly playing the role of the fibre of the web connecting, interweaving, and facilitating interactions within and between levels. With this perspective,

interactions between students and between students and teachers, mediated both with and without technology, were examined.

Complexity thinking is being drawn upon, in part, to address the lack of theoretical grounding used to approach and interpret studies of social media and learning. Bates (2011) acknowledged that "Web 2.0 tools are so relatively new to education that educators have yet to find new designs for teaching and learning that fully exploit such tools. Most uses to date have been within the framework of a teacher-controlled model of instruction." (p. 26). Bates (2011) suggested that social constructivism theory (e.g., Gould & Brown, 2003) with its learner centered instruction and communication between learners, and connectivism (e.g., Siemens, 2005) with its emphasis on digitally co-constructed knowledge may have much to contribute in designing pedagogies for developing 21st century skills. In Attwell and Hughes' (2010) literature review of pedagogic approaches to using technology, a wide range of learning theories were summarized, however their application in the area of creating pedagogies for learning with technology were not offered, perhaps because the examples do not yet exist. Finally, Williams, Karousou, and Mackness (2011) wrote a compelling theoretical paper which proposed that

> space needs to be made for substantial, self-motivated, self organized, emergent learning…as a vital part of a learning ecology that includes both emergent and prescriptive learning in a world in which Web 2.0 platforms offer unprecedented affordance for information, interaction, networking and collaboration as well as for unique challenges. (Sec. 5, para.7)

Williams et al. (2011) proposed a framework for defining and managing emergent learning by drawing on complexity theory (Cilliers, 2005), connectivism (Siemens, 2005), and communities of practice (Wenger, 1998). Their framework was applied to gain understandings of empirical data collected in three cases of learning. Williams et al. (2011) drew more heavily on complexity theory than on connectivism and communities of practice because it provided a useful framework for drawing distinctions between emergent and prescriptive learning. Connectivism (e.g., Downes, 2009) and communities of practice (e.g., Aceto, Dondi, & Marzotto, 2010) have been used to analyze the ways in which learning is enabled by social media. However, in the current study complexity thinking (Davis & Sumara, 2006) was used as a transdisiplinary framework that has been applied more generally in the field of education (than connectivism), and which recognizes the social learning that occurs in communities of practice as part of the

complex system of learning which also includes learning at other levels (i.e., student, teacher, school, administration, cultural, etc.). Complexity thinking allows us to ask questions about learning such as: How are social media embodied in students' everyday experiences and into their learning experiences? How can social media facilitate the emergence of ideas from collectives of students, and how can teachers promote the kinds of experiences that enable emergence?

Research Questions

There is an established need for empirical work in the area of social media practices that has been approached from a theoretical perspective on learning. Thus this study explored the following research question from a complexity thinking perspective:

1) What social media resources do secondary and post-secondary students draw upon as they learn science? How and why?

Research Context

The study of student use of social media was carried out in British Columbia, Canada and spanned several schools in several school districts and included two post-secondary institutions.

Provincial Context: British Columbia, Canada

In Canada, the responsibility for education rests with the provinces and territories. The education system includes public schools under the direction of the local school boards and the provincial Ministry of Education, as well as independent schools. The province of British Columbia is divided into fifty-seven public school districts with approximately 641,600 students (Ministry of Education, 2012b). Over the course of the past year, the British Columbia Ministry of Education has been attempting to roll out new educational initiatives based on the concepts of 21st Century Learning and personalized instruction. Some of these plans address standards, policies, and practices with regard to mobile devices. For example, in the Ministry of Education's (2012a) "2012/2013 Transformation + Technology Update", the province committed to:

- "Establishing a technology forum to exchange information and ideas between the education sector partners." (p. 18)

- "Piloting the Bring Your Own Device (BYOD) model to determine what works in standards, policies, and best practices." (p. 18)
- "Working to create more mobile options for staff, such as participating in a pilot for expanding the range of mobile devices with Shared Services BC." (p. 19)
- "Exploring the BYOD approach in the Ministry through a partnership with the Office of BC's Chief Information Office" (p. 19)

While the "2012/2013 Transformation + Technology Update" makes overt references to mobile devices, there is little consideration given to how educators might pursue harnessing the power of Web 2.0 and social media for education. For instance, in BC the Ministry of Education (2012a) in conjunction with the BC Association of School Business Officials found that while almost 90% of BC schools "have some wireless access and many students had internet-connected devices, but …[there was no] common strategy that would let students use them to enhance learning at school" (p. 12).

Study Context

Focus group interviews were held with students sampled from three populations of physics students. Upper year post secondary physics students, first year post secondary physics students, and secondary physics students. Participants (n total = 34) were recruited from a range of physics learning contexts such as both independent and public high schools, and small and large universities in British Columbia (BC), Canada. Demographic information is summarized in Table 1.

Table 1

Demographic Data for Focus Group Participants

Focus Group Type	Number of participants	Number of Focus Groups	Other information
Secondary physics students	24 (12 female, 12 male)	5	Focus groups took place in two schools, one independent and one public school in Vancouver, BC.
First year post secondary physics students	7 (all male)	2	Focus groups took place at a small teaching university in BC.
Upper year post secondary physics students	3 (1 female, 2 male)	2	Focus groups took place at a large research university in BC.
Total	34	9	

Methodology

The study was designed as an exploratory, interpretive multiple case study (Schwandt, 1998; Stake, 1995) aimed at gathering data about how science students use social media for science learning from science students in several contexts. Data were gathered through focus group interviews with three populations or cases: secondary (grade 11 and 12) physics students (n=24), post secondary introductory (first year) physics students (n=7), and upper year post secondary physics students (n=3). Demographics of participants are described in Table 1. Data from each case were compared and similarities and differences were identified.

The focus group interviews were a preliminary study of an international collaboration in science education focusing on social media and science teaching and learning, thus they were conducted with physics learners. The aim of the focus groups was exploratory, to determine what kinds of social media tools students used when learning science and how they used them in order to inform the development of a survey for the second stage of the project. The survey will be administered to science learners, including secondary and post secondary students, and pre-

service science teachers in several local and international contexts. A range of populations were sought because one of the aims of the international collaboration is to examine changes in how students use social media for learning depending on their level of scientific study.

Focus group interviews (n=9) were run by one of the researchers (Moll). Interviews were typically about half an hour long, and occurred at the school or university the participants attended. Following a semi-structured interview protocol, exploratory data were collected about how the participants used social media both within and outside school contexts to support learning. Students were asked to list which social media sites they used, to describe how they used social media and online resources when they were stuck on a physics problem, and about how their teachers used social media in their classes. Focus groups were video taped and transcribed verbatim for coding, theme searching, and interpretation. The coding, identification of emergent themes and interpretation process were guided by qualitative data analysis software, *Atlas Ti*, and a complexity thinking perspective on learning (Davis & Sumara, 2006). Emergent themes will be reported on in this paper and were used to develop a survey, the Social Media and Science Learning (SMSL) survey – a survey that will be administered more widely in subsequent stage of the project to study social media and science learning from a student perspective.

Results

Three types of focus group interviews of physics students were conducted: secondary students, first year post secondary students, and upper year post secondary students. In each focus group, students were asked some demographic information such as why they were taking physics and the types of technologies that they had access to.

The secondary students (n=24) were recruited from two different contexts. Two male Grade 12 Physics students were interviewed at an independent high school in Vancouver, BC. The remainder of the sample were students who were taking Grade 11 Physics at a public high school in an affluent area in Vancouver, BC. The Grade 12 students who were interviewed were taking physics because of their goals of pursuing engineering or business programs at university. Grade 11 students' reasons for taking physics were more varied: some took it to keep their options open; some because it was expected in their peer group or by their parents; and some had science and/or math related interests or career goals. More students found physics difficult

(n=13) than easy (n=8) (not all students answered the question), but most had neutral or moderately positive attitudes towards physics. Focus group interviews were held in October when most of the participants were just two months into their first dedicated physics course (Physics 11). Thus strong student perspectives and attitudes towards physics had not had much time to develop. All of the secondary students who participated in focus group interviews owned their own computer, almost half (n=11) owned a smartphone and some (n=5) used an iPod touch or tablet to access the Internet. Most students (n=18) said that they were members of Facebook and had been since middle school (Grade 7 or 8).

Ten post secondary students participated in four different focus group interviews. The post secondary physics students fell into two sub groups: upper year students and first year students. In the upper year sub group there were three students who were finishing honours physics degrees at a large research intensive university in Vancouver, BC. All three of these students owned their own computer and were members of Facebook. Two students had a smart phone device that they used to access the Internet. Seven first year students were also interviewed. All the first year students were male and were recruited from introductory physics courses at a small teaching university on Vancouver Island. Most of these students were science majors, but only one might major in physics. The others said that they might major in computer studies, engineering, or biology. When asked if they found physics easy or difficult, most first year students said that it depended on the context. While most first year students were taking physics as a required course in their science degree, some said that they were interested in physics and enjoyed it. Thus, this group of physics learners, who volunteered to participate in the study, had generally positive attitudes towards physics so far. Similar to the high school students, interviews with first year university students were conducted in September thus students were only just starting their first university level physics course. All seven of the first year students owned their own computer, some (n=3) owned a smartphone and most (n=6) were members of Facebook. Thus, of all the students interviewed, the demographics were surprisingly similar: all students owned their own computers; most, but not all, were members of Facebook; and about half owned smartphones. These findings were consistent with large scale surveys of students in these age groups (e.g., Clark et al., 2008; Watkins, 2009) – Facebook use was prevalent, but not all students had access to mobile technologies.

Besides demographic information about the kind of physics learner and technology user they were, students were asked to describe how they used technology for physics learning purposes. Themes emerged within three broad areas: (a) use of social media tools, (b) personalized physics learning, and (c) teachers and social media use. Some specific themes from each area will be presented.

Use of social media tools. When students were asked to describe the types of social media resources they used for learning physics a wide variety of tools were named. A tally of the most frequently discussed resources during the course of the focus group interviews is presented in Table 2. Note that not all the resources in Table 2 are social media tools (i.e., bookmarking), but can be used in social media kinds of ways (i.e., Delicious for social bookmarking).

Table 2

Frequency of codes for social media tools that students mentioned in focus group interviews.

Technology	Code frequency	Technology	Code frequency
Facebook	54	Course Management Systems	9
Videos (i.e., YouTube)	38	Bookmarking	7
Online forums (i.e., Yahoo Answers)	34	Skype	6
Google	27	Wolfram Alfa	5
Twitter*	17	Cloud Computing	4
Wikipedia	15	Reddit	4

*Findings indicated that students do not use Twitter much (socially or academically) but Twitter was discussed in each focus group because the researcher asked about it.

Student use of Facebook, videos, online forums and Google were high, thus some trends within each of these categories are discussed in more detail below.

According to the students, Facebook was their primary communication tool. It was preferred over email and in fact, some of the secondary students said that they did not even know their close friends' email addresses. A post secondary student attempts to explain the phenomenon:

> I find that I send like an email to people and sometimes they don't respond. And sometimes it takes two or three days for them to respond. But if I send them a message on

> Facebook, they will respond immediately. When I get a message on Facebook…I feel like I have a responsibility…a social responsibility to [respond]. It's almost like when I'm talking to a person at a party. [upper year post secondary student]

Secondary students said "Yeah, I don't check it [my email] like every day. Like if you want an instant response, you would Facebook message someone" and "I still have to check it [my email] sometimes because teachers like using it."

Given that Facebook is a major communication tool, students often used it to chat online about their homework and assignments. When students were asked what they did when they were stuck on a physics homework question 71% said that one of the first things they would try was chatting online with a friend. Facebook was the most frequent chat client that they named but other tools were sometimes used such as MSN and Skype. Students acknowledged that chatting online about physics homework was challenging, particularly when equations and symbols were needed, but it was still one of the dominant coping strategies that students used while they were working on their physics homework.

Students also talked about Facebook most frequently when they were asked for suggestions about how their teachers or instructors could use social media in their teaching. Some students could describe instances that they had heard about where teachers had used Facebook as a way to communicate with their students, usually through a Facebook group. Some students suggested that teachers develop a presence on Facebook, usually so that they could be more accessible for students' questions:

> I think it would be cool if they had like a Facebook because they only have a certain amount of office hours. But if you were on Facebook, you could just talk to them anytime you want kind of thing. And it's a lot quicker than email. And you wouldn't have to wait for them. [first year post secondary student]

But other students did not like the idea of mixing school with their social life:

> I know that they have email, but I wouldn't want to add them [teachers] on Facebook as a 'friend' because that's just really weird. I don't think that I really want them in my social life except for part of my education part of my life. [secondary student].

Secondary and post secondary students talked about Facebook in the same ways and with similar frequency and emphasis. For all of the groups interviewed, Facebook played an important role in the ways their social network supported their academic work.

Videos were a heavily accessed social media resource. Students in each focus group agreed that they sometimes used videos to learn physics and a little more than half (n=13) of the secondary students specifically cited online videos as a resource that they consulted when they were stuck on a physics problem. Some students used video to clarify a concept:

> People post video lectures online on YouTube. They are also sometimes helpful as a supplement to what you are learning. MIT has a bunch of lectures they put up. I usually [watch] when it's really confusing….not only are they good for Physics but I also find they have put like a bunch of other ones as well. [upper year post secondary student]

Videos were used to review a concept:

> I think most of my learning that I get done is in the classroom setting but these videos seem to be like refreshing, like just to remember what you've done before. [first year post secondary student]

Or to learn more about a concept:

> It's mostly for my own entertainment too. I'm not always convinced that I'll have a better understanding maybe because of it but, I'll find somebody and think "Oh, yeah! This is really neat!" and, I'll try to find another one [video] that explains it even better at that point. [upper year post secondary student]

However, secondary students were more likely to use videos to find the answer to a physics problem:

> Researcher: If you are stuck on a physics problem, what is the first thing you will do?
> Student 1: I'll YouTube it. I look at the chapter, the questions in it and usually there's a video. Like a math tutor.

Both secondary and post secondary students used videos that they had found online to support their learning. They gave similar reasons for using video:

> I think the big thing about having media to do that is, you know that you could access it anytime you want…Like I can't tell a prof, "You want to stop now?"…with videos I could. [first year post secondary student]

> Student 1: [Videos help me learn] because like when we're in class we have to like listen to the teacher but we have the choice not to because like we don't really want to. And then when we're self-studying, like when we're on the computer, we're like focused on one point. So I guess we're like concentrating on that video or like information.
> Student 2: The video gives much more information.
> Student 3: You can't exactly press pause on the teacher and go back and… [secondary students]

Some students appreciated the visual capabilities of video, however in the physics learning context, simulations and animations were rarely used and most of the videos students viewed were 'chalk and talk' style lectures. Students said that you could find a video lecture on almost anything online, but recognized that resources "need to be compiled better" and that "a professor knows if a video is actually true". Several secondary students talked about online tutoring sites such as the Khan Academy, which have videos and worksheets, and found them very helpful for independent learning. "He has notes and stuff as well so that while you're

watching the videos you can look at his notes and stuff". Some also clearly prefer the visual learning style of watching videos:

> For me overall to watch something in a video, I learn a lot from that instead of just listening. It's the same thing if the teacher does an experiment, it's easier to understand and to learn. So if I watch a video on YouTube, I learned it a lot easier [secondary student]

In the process of learning physics students clearly spend time looking for and watching videos online. Some suggestions students had for incorporating these activities into their more formal schooling was for teachers and professors to recommend videos, and also for teachers to create videos of their classes and lectures that students could access. Students, however, did not advocate for the replacement of classes with videos. Students valued coming to school, in part for social reasons, and having a teacher to consult with. "The fact that the teacher is there and we're interacting with him and we can ask, we can ask him questions that can be answered that can't be answered online." One student said that they thought personal interaction was better and that teachers were there to answer questions. A secondary student said "I like learning from a teacher. Like having them verbally teach it to you rather than reading it from a textbook. And it's fun learning together in a group."

While students in both secondary and post secondary education tended to use Facebook and online videos in similar ways, student use of online discussion forums was markedly different between these two groups. Thirteen or 54% of secondary students said that they used online forums or question and answer sites such as Yahoo answers or Answers.com, whereas only 3/10 or 30% of post secondary students said that these kinds of sites were helpful, and these were all first year students. None of the upper year physics students mentioned these sites. Secondary students also relied more heavily on Google (75%) than post secondary students (57%). One first year student said that they liked learning online because "You can type in exactly what you want to know and you can find it out." Secondary students described their strategies:

> I just Google like a really stupid sentence, question like, "How do you do this Physics question?" And then, see if it's on Yahoo answers.
>
> Student 1: I'll type something in [to Yahoo Answers] and usually like someone's asked that question.
> Student 2: There's also like, if you ask a question and wait for someone to answer…for if you want some more answers.

Secondary students recognized that it was difficult to Google the answers to physics questions:

> The equations ones, there's like really hard to find some of the answers. It's like, "Oh, my God! I don't understand what I'm doing!".
>
> If it's stuff like that where I can't really Google it then, I just ask my online friends.
>
> Researcher: Do you find the right answers, or the solutions that you're looking for?
> Student 1: Sometimes. For physics, it's kind of hard.
> Students 2-4: Yeah.
> Student 1: I tried yesterday and it didn't really work.
> Student 2: Sometimes if you put too many words in or, like you're not specific enough, they give you too broad…
> Student 1: And also because we're in Physics 11, whereas like the…and a lot of the Physics is like really advanced. So it doesn't help me understand it.

Results from focus group interviews support claims from the literature (e.g., CIBER, 2008; Clark et al., 2008) that today's students increasingly need immediate, easy to find, and surface level solutions. Though many students recognized that Googling for physics answers does not work very well, the majority still said that it was a strategy that they frequently used. However, students were twice as likely to say that they would ask a friend (in person or virtually) before asking Google or posting the question online. In addition, it seemed that secondary

students used the Internet in a mostly Web 1.0 way, to find information that is stored there and use it to help them with their homework. They much more frequently searched for and read sites like Answers.com than they contributed to the community. However they appeared to recognize and value knowledge created by mass collaborations and were more likely to trust sites that were popular and frequently contributed to such as Yahoo Answers and Wikipedia, rather than an unrecognized source. A secondary student said, "on the Internet, if you go into Wikipedia, since so many people have contributed to it, you actually get the full thing. Instead of just kind of part of it. And it makes sense more." Post secondary students, on the other hand, particularly the upper level physics students, were more likely to use social media and online resources to gain a deeper understanding of a concept and were less likely to be 'looking for the right answer'. For example, one first year post secondary student described the difference between learning using technology in high school and in university:

> In high school, the teacher gave you a lesson and you just kept that and you just stay there. You don't go beyond that. Here [at university], you have to go…for me, I don't know, I have to go beyond that. So I have to look for other sources to get more information and support my knowledge. It helps us to know like more about it even if it's not relevant to answering the questions. So you're not just parroting things back.

Personalized physics learning. Without calling it 'personalized learning', students talked about being able to have the flexibility to tailor their learning programs. A secondary student said: "I think that on the Internet, a lot of times, it's, especially if you are asking questions, it's specifically tuned to what you want instead of the teacher who just teaches the general topic". They talked about the frustrations of learning physics in a classroom environment:

> sometimes they [the teacher] are moving too fast. And sometimes it feels like they're not moving at all. And yeah, so sometimes you're in class and doing the same thing over and over again. I think it's because it's like everyone has their own pace in their learning and their own like how they want to learn and methods and stuff so, it's like a teacher can't

> adjust to like every single one of the students. Which is like really hard. [secondary student]

One secondary student described how she learned specific singing skills from YouTube because "the [choir] teacher cannot focus on specific people, so it's better to watch the video."

Upper year post secondary physics students discussed how they pull together resources to become self-directed learners since they rarely found their on-campus lectures helpful. Some secondary students enjoyed taking online courses because "you could work at your own pace and do like whatever you want. If you wanted, you could get like English done in a week.", while other students recognized that they needed the structure of class meeting times. An upper year post secondary student said: "The Internet, for learning, it isn't structured at all and like, you can do whatever you want and you can find whatever you want. But sometimes you'll go off on a completely wrong course and learn something that doesn't really help you."

A first year post secondary student talked about how much he valued being able to get a second opinion and view different perspectives on a topic, and how having access to the Internet had impacted his learning:

> It [the Internet] makes the topic more interesting. Like if I were to just be going off of the Physics that I have learned from high school, I probably wouldn't even do Physics at all. But like university stuff or sometimes you know the Internet is much more interesting. So I probably wouldn't even be pursuing this if I hadn't known about that.

Students were asked what steps they took when they were stuck on a physics problem. While some clear trends emerged that have already been described, another result was the diversity of strategies students used and that the order in which students accessed them varied widely. Only four students total talked about using the textbook if they got stuck. A secondary student said: "I don't like the text book. I don't know. It's like long and they use big words and they use big paragraphs. I think that if they shortened it where they just gave us really important notes and a lot of pictures that would make more sense." Only one student mentioned asking the teacher. Therefore, using an array of social media and other learning and communication tools, students develop their own personalized learning support system that is likely tailored to fit the

needs of the discipline they are learning and the context in which they are learning (secondary or post secondary).

Teachers and social media use. Secondary and post secondary students were asked about whether their teachers used social media in their courses and how they would like their teachers to use it. Students in all age groups agreed that their teachers did not frequently use social media as teaching tools. The only example of social media use from the post secondary students was the use of YouTube videos in lectures and posting of assignments and information on course management systems. One upper year post secondary student described how some mathematics professors used Twitter: "They would talk about, you know, the problems that they would encounter in their work, and it's just a conversation group between a few people [upper level and graduate students]". Some of the post secondary students said that it would be nice if they could talk to their professors online, as opposed to office hours. One said, "Chat might be more of a good thing. It might increase like, not coming physically to visit them, but to ask questions in the same way".

The secondary students who were interviewed had more examples of how social media had been incorporated into a variety of their courses at school. Most of the students who were interviewed attended the same school, so the results represented a narrow perspective on what teachers may be doing with social media at the high school level. Students said that they had contributed to wikis as part of an assignment and had teachers who maintained blogs. The Grade 12 students attending the private high school said that one of their teachers was willing to meet students via Skype to provide extra assistance during an extended period of absence from regular classes. The teachers who had blogs used them to disseminate coursework and information, not in interactive ways (i.e., to hold discussions or allow student contribution and commenting). Students talked about doing online mathematics problem sets: "In Math, they give us like a problem set to do online, but they say "Go to this link." But it's hard to do because the link is actually in the text book and we're not allowed to take the textbook home." In one case, students described a science teacher who posted a presentation online after class. They said: "It's better, if the teacher is going too fast in class, and she is video-taping it then, you can pause it and figure out what is actually going on in the question and break it down." Students also said that when YouTube videos were used in class and the links were made available that they would go and re-watch the videos when they were studying.

Discussion

The results of this focus group study of students' perspectives on social media and science learning demonstrated that student use of social media tools were wide ranging and ubiquitous, but that the tools were not being used in creative and collaborative ways to support their science learning. For example, it was somewhat surprising that only one student, a post secondary student, talked about having a course related Facebook group, where students could meet, chat, and share ideas and content in a centralized place. Such a group could be an emergent artifact of students connecting online for their learning and could be a generative learning tool for them to use both within and outside the scope of their regular assignments. However, most had not created or participated in such a space. Interpreted from a complexity thinking perspective on learning, it was concluded that students were, in most cases, not describing uses for social media tools that optimized the tools' possibilities for co-constructing knowledge and emergent learning opportunities. Students at the post secondary level were more likely to recognize and partake in these opportunities. They were more likely to say that they used tools such as online videos and discussion forums to get a better understanding of a complex concept or idea. One notable instance was a first year student who said that he used Internet sources to get a diverse array of perspectives on what he was learning and that having access to supplementary physics resources had made a significant difference to his interest level and engagement in the subject matter. Secondary students, on the other hand were more likely to use social media tools to find the answer to a question either through asking a friend or Googling it to find an answer that had been previously posed on an online question and answer forum such as Answers.com.

The implications for these results are that teachers need to be aware of the level of sophistication with which students are engaging with social media tools. Simply knowing that they are using them is not sufficient to be able to design pedagogies that will build on students' experiences. It is necessary to determine in what ways students are using social media for particular types of tasks. The current study examined primarily how students use social media when working on physics homework problems. Students may use social media in a wider variety of ways in different disciplinary contexts, but for physics learning they have yet to

develop strategies to adapt their studying and learning practices to include some of the possibilities that connecting with others with social media could provide.

Students were, of course, constrained by the existing structures of traditional schooling, where most physics homework problems are assigned out of textbooks and most work is assessed individually. Student reticence to engage in, or perhaps talk about engaging in, collaborative efforts online to support their learning may have stemmed from a concern that they would be judged as having cheated. For example, in 2008, a first year student was charged with cheating for running a Facebook group (CBC News, 2008). While the researcher was not the students' teacher, most of the secondary students who were interviewed were high achieving students from an affluent community who would likely not want to risk their academic success by disclosing their online behaviours in a research interview. However, the results of the focus group interviews do support previous research in the field that has established that while students spend a lot of time on social networking sites and know how to navigate online spaces, only a small percentage actually fully participate by creating content for blogs, commenting in discussions, and designing personal learning spaces (Beetham, McGill, & Littlejohn, 2009). Follow up research in this area will be conducted in the form of an anonymous survey which may yield different results about how much students collaborate and share their ideas online.

A key result from focus group interviews was that students used social media tools in different ways, but most enjoyed the ability to be able to learn the way they want to, in their own independent and personalized way. Social media and Web 2.0 technologies provide many possibilities for designing personalized learning spaces or plans. However, students need to be supported in this effort, as they do not have the skills and expertise to design effective learning spaces, particularly in managing the connective and collaborative powers of Web 2.0 technologies. Williams et al. (2011) drew on complexity thinking to propose some strategies for managing emergent learning with social media such as developing negative constraints (i.e., specifying what is not allowed to happen), rather than what is allowed to happen. Davis and Sumara (2006) called this practice creating enabling constraints. A mechanism for being able to make mistakes and to learn from them is another strategy that Williams et al. (2011) described, which is also similar to the positive feedback loops that Davis and Sumara (2006) say drive a complex system closer to the state of instability where emergence, or learning, can occur. Thus by applying principles of complexity thinking recommendations for implementing pedagogies

for learning with social media in classrooms can be made. In British Columbia, personalized learning is the central idea in the Ministry of Education's current Education Plan (2011) and thus in the local and provincial context of this study, ways to enable personalized learning to occur are becoming increasingly important.

Similar to previous research (e.g., Watkins, 2009), social media and Web 2.0 resources were being used by students to connect with people in their existing face-to-face social networks. Particularly when they needed support with their learning, they used online tools to interact in ways similar to how they would interact with their peers in person at school. It is important to note that students communicated frequently with each other and that they expected communication to be fast and convenient. While email may appear to be a form of instant digital communication, to secondary and post secondary students it is not their primary form of communication. Teachers and instructors need to be aware that their emails may go unread or unnoticed for days, while Facebook notifications are usually quickly acknowledged. The results of this study indicated that teachers and other stakeholders in the education system need to become aware of how students are communicating and what their preferred communication tools are. Teachers are often trying to find effective ways to ensure that communication is clear and effective between students, parents, and teachers. Social networking tools could be used to facilitate clear and open communication between students, parents, and teachers and to build a sense of community.

Focus group interview results also provided insight into how some teachers are using social media resources. Post secondary students believed that their physics courses in particular lagged behind in terms of the incorporation of new technologies compared to their experiences in other subject areas (such as Biology and Math). Physics courses were less likely to have any kind of online assignment submission and had very low participation in online discussion forums on classroom management systems. Secondary students were able to provide examples of teachers who had used social media tools such as blogs and wikis as communication and assessment tools, but they were not used in collaborative ways. Information was disseminated on blogs, not constructed with students' comments and perspectives; wikis were used as individual assessment tools, not as a space for students to collaborate and create. Similar to students, teachers were constrained by traditional school curriculum and pedagogical structures, however no data was collected on schools' policies and procedures regarding social media. Complexity

thinking troubles the theoretical foundations of traditional schooling structures such as imperialism and behaviourism, and views knowledge as dynamic, learning as a process of adaptations to fit appropriate context, and teaching as opening the space of possibilities (Davis, Sumara, & Luce-Kapler, 2008). A complexity thinking perspective has much to contribute to the design of generative, meaningful online learning spaces that work in concert with more traditional, prescriptive learning spaces that exist in current schooling structures. Although research has yet to demonstrate its effectiveness, supporting teachers in the development of a complexity thinking perspective on knowing, learning, and teaching and expertise in working social media and Web 2.0 technologies would allow teachers to optimize new technologies for their capabilities to create generative learning spaces that meet the needs of 21st century learners and curriculum.

Conclusions

The main conclusions of this student focus group study were that secondary and post secondary students, and their teachers used social media, but not in ways that significantly improved the in-school or out-of-school learning environment. Both students and teachers need support to enhance the ways that social media are used for science learning and for teaching in general. Applying complexity thinking to understand the ways in which social media tools can allow for emergent learning may help teachers to use social media tools to support students in designing personalized learning spaces for themselves. These spaces should be tailored for specific disciplinary learning contexts.

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