Development and Validation of a Social Media and Science Learning Survey

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Introduction

The first generation to grow up surrounded by social media has reached a metaphorical age of graduation. It has been suggested that 'digital natives', those born since 1980, are a new generation of learners with different skills and interests (Prensky, 2001a, 2001b, 2005). Contemporary critiques argue that these claims are inadequately supported empirically or theoretically (Bennett, Maton, & Kervin, 2008; Jones, Ramanau, Cross, & Healing, 2010; Kennedy, Krause, Judd, Churchward, & Gray, 2008), yet claims about this generation of learners have still led to calls for change in education systems. Further, a homogeneous generational lens has been applied to most studies of youth's online activities (e.g., Kennedy et al., 2008) and inherent in critiques about research claims regarding 'digital natives' is a need to unpack and better understand the diversity of social media practices *for learning* among this generation of learners.

In this study we draw on complexity thinking (Davis & Sumara, 2006) as a theoretical framework for learning in order to describe how social media applications can be used as learning tools. Complexity thinking allows us to: (a) describe learning systems using characteristics of complex systems, and (b) examine existing conditions that may allow for emergence (i.e., learning) to occur. The conditions of emergence in complex systems allow for the components of the system to interact so that a whole can emerge that is greater than the sum of the parts. The result is that the system can be "smarter – that is, capable of actions, interpretations, and conclusions that none would achieve on her or his own" (Davis & Sumara, 2006, p. 136). Previous work by Moll, Nielsen, and Linder (in press) developed and applied an analytic framework using the conditions of emergence to describe learning with social media tools. This work suggested the need for more basic understanding of social media usage for learning. Thus, we developed a survey to gather data from larger populations, which was purposeful in asking questions to indicate *which* tools are being used and also examines *how* they are being used in science learning contexts.

The purpose of this paper is to describe the development and validation of a survey designed to examine science students' social media learning behaviours. The extent to which today's youth

participate in activities that connect them to each other and to information is vividly apparent, but do we as science educators understand how students utilize the potential of this connectivity to benefit learning? To begin to understand how students actually use social media in their learning activities, we developed a survey to gather information on students' use of social media for learning science. The survey development is part of a larger study that aims to understand social media practices across age groups and contexts and seeks to develop a model for understanding science learning through social media.

Social Media Use

Research into social media use and learning generally begins with an examination of how frequently students are using social media. However, the most recent reports of social media use among teens acknowledge the challenge of trying to determine frequency of use as findings indicate that 24% of teens access social media sites "almost constantly" (Lenhart, 2015), largely due to the increase in access to smartphone technology. While Facebook is still the most popular social networking site, Lenhart indicated that teens are diversifying their social network use to include Instagram, Snapchat and Twitter. A recent report of college-age users found a declining trend in Facebook use; a trend that is predicted to continue (Blodget, 2012). Another trend that has been identified is the drop in email use among youth and young adults; a 59% decrease in email use among 12-17 year olds in 2010 was observed (comScore, 2011).

A homogeneous generational lens has been applied to most studies of youth's online activities (e.g., Kennedy et al., 2010). The findings of many large scale studies of youth and social media vividly capturing the extensive use of social media applications, such as Facebook, but also reveal that this use is not nearly as sophisticated as has been imagined (e.g., Ito, Baumer, Bittanti, Boyd, Cody, Herr-Stephenson et al., 2010; Jones, Ramanau et al., 2010; OECD, 2012). 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, Steinfield, and Lampe (2007), or interest-driven practices. Oblinger and Oblinger (2005) claimed that this generation of learners prefer active learning to passive learning, while Prensky (2001a) argued that they want to receive information quickly and Brown (2000) suggested that they are skilled at so-called multi-tasking. However, research has also shown that learners rarely take advantage of the collaborative and creative potential of Web 2.0 technologies (Moll et al., in press) and critiques have argued that these claims are inadequately supported empirically or theoretically. In addition it is important to recognize that application of these technologies for learning are strongly influenced by teachers and instructors (Bennett et al., 2008).

We argue that teachers are best situated to influence students' use of social media for learning purposes when they have an understanding of students' social media practices for learning and can leverage and/or support students to develop their ability to benefit from their high levels of connectivity. Many studies have identified the ubiquity of social media use and what tools are being used, but what do we know about how students use social media in learning contexts?

Social Media Use and Learning

The potential value of social media resources in educational contexts has been recognized. For example UK's education think tank, The Education Foundation, has published *Facebook Guide for Educators: A Tool for Teaching and Learning* (Fordham & Goodhard, 2013). Although the guide was commissioned by Facebook, there are other indicators that social media has become a significant type of educational technology including research compilations such as *The Social Classroom* (Mallia, 2014) and Tess's (2014) recent review of the role of social media in the higher education classroom. In 2010, Selwyn proposed three interrelated concepts in order to justify the use of social media in higher education contexts: the changing nature of the student who is highly connected, collective and creative; the changing relationship that today's university has with knowledge consumption, knowledge creation and formal education; and, the emergence of 'user driven' education.

Most research into social media use and learning has been undertaken in higher education contexts and it was noted by Kandroudi and Bratitsis (2014) that no methodologically structured empirical studies have been conducted in lower levels of education. Claims have been made that social network use can lead to more complex communication patterns (Schroeder & Greenbowe, 2009) and even to higher engagement and achievement (Junco, Heiberger, & Loken, 2011) but there have also been calls for more consistent application of a theoretical framework for implementing the technology as a learning resource (Merchant, 2012). A recent review of Facebook use in education found that "the pedagogical affordances have only partially been implemented" (Manca & Ranieri, 2014, p. 313).

Faculty use of social media can only be described as superficial where research indicates that Faculty use social media more for personal than instructional use and that their main use is consumptive – most often sharing online videos in their classes even as they acknowledge that social media can be effectively used by students for collaboration (Moran, Seaman, & Tinti-Kane, 2012). However, Faculty are sceptical about the pedagogical value which can be attributed to a disconnect between the informal and colloquial sharing of information that social media are designed to promote and the professional relationship that faculty tend to value (Martínez-Alemán, 2014).

Facebook is the most widely used social network, and thus is most widely studied (Tess, 2014). Some work has focused on affective outcomes or examined the relationship between learning outcomes and student achievement and the educational use of social networks. Common results include evidence that students rarely used social media for educational purposes, preferring to have a separation between their personal/social lives and their academic lives (e.g., Jones, Blackey, Fitzgibbon, & Chew, 2010; Madge, Meek, Wellens, & Hooley, 2009). Other researchers found that social networks facilitate more effective communication between peers (e.g., Brady, Holcomb, & Smith, 2010) and help students to build relationships (McCarthy, 2010), while others concluded that instructors needed to involve students in critical engagement in order to facilitate posts that were 'horizontal' or 'liberating' (Rambe, 2012). Interestingly, negative relationships have been found between social network use and student achievement (e.g., Kirschner & Karpinski, 2010; Paul, Baker, & Cochran, 2012). However, other studies show mixed results (Pasek, More, & Hargittai, 2009). While literature is continuing to build in the area of social network use, specifically Facebook, in education it is also necessary to broaden the scope of work that is examining social media use in education in order to account for the diverse tools that students may use to support their learning.

In addition, there is little work on social media and learning conducted in the specific disciplinary contexts. Most of what has been done has been in the area of language learning (Manca & Ranieri, 2014). For example Saykili and Kumtepe (2014) examined the use of Facebook as a support tool in foreign language education and Kabilan, Ahmad and Abidin (2010) found that Facebook could assist students to practice writing in English. As potential affordances and drawbacks of social media use have been examined for language learning, there is further need to study learning in specific contexts such as for science.

Social Media and Science Learning

Research has reported on and examined the impact of social media tools in science learning contexts. Some have used social media to improve science attitudes and engagement (Wilson & Boldeman, 2012) or ecological and environmental awareness (Karahan & Roehrig, 2015; Robelia, Greenhow, & Burton, 2011). Other studies have examined the ways in which social media can facilitate particular ways of thinking such as creative thinking. For example, Smith (2014) reported on the impact of providing undergraduate chemistry students with the opportunity to make a YouTube video to communicate their understanding of an organic chemistry concept. He noted that the process of generating the video enthused students and helped to develop creativity and communication skills. Jang (2009) examined the effectiveness of stimulating creative thinking in secondary students using a

variety of web-based activities that integrated real-life scientific materials and contexts. He found, for example, that students were stimulated by interactions with their peers, came up with more creative thinking and ideas when completing online homework, and that students demonstrated flexibility and originality in the process of engaging in online homework activities. Apiola, Lattu, and Pasanen (2012) created a conceptual framework for supporting creativity based on theories of intrinsic motivation, domain relevant skills, and cognitive processes and designed creativity-supporting learning environments in computing education. They found that in these contexts students used deep and surface approaches to learning and problem solving. Finally, Van Eaton, Clark and Smith (2015) examined the ways students articulated their physics reasoning in online forums and face-to-face collaborations and found different patterns of articulation where students were more likely to employ formal physics reasoning in online forums than in face-to-face collaboration. The development and validation of a Social Media and Science Learning Survey is a contribution to the field of science education where little is known about how students use social media resources to support their science learning.

Method

Survey development followed an inductive approach (Brinkman, 2011; Mansourian, 2006; Strauss & Corbin, 1998) that addressed issues of credibility, consistency and transferability (Merriam, 2014). Our method is based on a grounded approach (Glaser, 1992) to develop the survey based on data gathered initially from focus groups with science learners. Through a systematic process, the survey was revised and refined. Results from focus group interviews (n=12) with a total of 43 students studying secondary and post-secondary physics in Canada and Sweden were used to develop the first iteration of the survey. Focus group interview questions identified the most frequently used social media tools and common behaviours when participants used social media tools to support their science learning (Moll, Nielsen, Hoban, & Linder, 2012). Results from focus group interviews were used to develop survey items. There are three key sections in the survey: demographics and everyday social media use; social media use in the science subject of interest (i.e., a first year physics course); and social media use in high school science learning. Within each science learning context (high school or university science), respondents are asked to self-report a level of proficiency with the listed social media tool. The respondents are also asked to respond to statements about specific social media behaviours for learning by indicating how frequently (never, sometimes, or regularly) particular behaviours are used. Examples of behaviours include: “When completing high school science homework I worked in front of my computer so that I could search the Internet and/or Google.”

Indications of frequency of use of specific social media behaviors for learning provide additional information about how the social media tool was actually used in respondents' science learning practices. Focus group results and social media behaviours for learning became the focus of questions throughout the survey.

Validating the survey involved a systematic process so that the final version served our goals to understand the phenomena of interest (Mansourian, 2006): capture social media practices in order to develop understanding of the phenomena of social media practices for learning. The initial survey was piloted in three post-secondary learning contexts in 2012 in three countries (pre-service teachers in Australia (Nielsen, Moll, Farrell, McDaid, & Hoban, 2013); tertiary physics students in Sweden; tertiary physics students in Canada. Piloting the survey across these three contexts offers some level of confidence for transferability. Validation interviews (n=4) in 2012 were conducted with Australian preservice teachers who took the survey in 2012 and revisions were made to the survey. The revised survey was administered in 2013 to another group of Australian preservice teachers and a second round of validation interviews (n=6) was conducted.

Results

Focus Group Results: Survey development

Focus group interviews with three types of physics students were conducted in the fall of 2011: secondary students in British Columbia, first year post-secondary students in British Columbia and Sweden, and upper year post-secondary students in British Columbia and Sweden. 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.

All of the secondary students (n=24) 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). All of the post-secondary students (n=19) owned their own computer, some (n=7) owned a smartphone and most (n=16) were members of Facebook. Thus, of all the students interviewed, the demographics were 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, Logan, Luckin, Mee, & Oliver, 2008; Watkins, 2009). Facebook use was prevalent, but not all students had access to mobile technologies.

When students were asked to describe the types of social media resources they used for learning physics a wide variety of tools were named. We tabulated focus group data in tables similar to Table 1, which shows a data summary from the Canadian focus groups of the most frequently discussed resources during the interviews. Note that not all the resources in Table 1 are social media tools (i.e., bookmarking), but can be used in social media kinds of ways (i.e., Delicious for social bookmarking).

Table 1

Frequency of social media tool use by Canadian students (n=34) *in focus group*s.

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 did not use Twitter much (socially or academically) but Twitter was discussed in each focus group because the researcher asked about it.

There were some similarities and some differences in the ways in which secondary and post-secondary students talked about using social media resources. 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 academic work. Given that Facebook is a major communication tool, students often used it to chat online about their homework and assignments. Key behavioural strategies with social media were offered when participants were asked what they did when they were stuck on a physics homework question. The majority said that their first response was to try chatting online with a friend. Videos were also a frequently 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. 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?

> Secondary Student: I'll YouTube it. I look at the chapter, the questions in it and usually there's a video. Like a math tutor.

Some students appreciated the visual capabilities of video, however in the context of learning physics, simulations and animations were rarely used and most of the videos students viewed were 'chalk and talk' style lectures. Participants 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." While students in both secondary and post secondary contexts tended to use Facebook and online videos in similar ways, student use of online discussion forums was markedly different between these two groups. More than half of secondary students said that they used online forums or question and answer sites such as Yahoo answers or Answers.com, whereas only about a third 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 than post secondary students. One first-year university student said that he liked learning online because "You can type in exactly what you want to know and you can find it out."

Without calling it 'personalized learning,' students talked in terms of having the flexibility to tailor their learning programs. A secondary student said: "I think that on the Internet, a lot of times, especially if you are asking questions, it's specifically tuned to what you want instead of the teacher who just teaches the general topic." This second student 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.

Students were also 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 in total talked about using the textbook if they got stuck, and this secondary student reasoned why: "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. Thus, it appears that students use an array of social media and other learning and communication tools and in so doing, 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).

This brief presentation of focus group results illustrates some of the key themes that informed the design of the survey. Firstly, there were distinct differences between secondary and post-secondary students, thus the survey was designed to collect information about both of these learning contexts. Secondly, some specific types of behaviours emerged from focus group interviews such as 'chatting with a friend on FB' or 'asking a question on an online forum.' Thus these behaviours became items in the survey. Finally in an attempt to try to capture the diverse methods that students use social media to support their science learning we asked students to rank the resources that they would use when they were 'stuck on a physics HW question'.

Structure of Survey Version 1 (2012)

The purpose of the *Social Media and Science Learning Survey* is exploratory, thus our process of development and refinement was largely qualitative. We used cycles of refining and piloting in addition to interviews with survey respondents to assess if the survey was capturing the kinds of information that it was intended to capture. In the sections that follow, we draw from survey results to characterize and refine the survey items and instructions to be as clear as possible.

Version 1 of the survey was administered during a class meeting of a science methods class that included the entire cohort of pre-service primary teachers in a four-year B.Ed. program at a university in Australia (n=220) in 2012. This population takes a mandatory science methods subject (EDKS) in the first year of the B.Ed. program and students volunteered to participate in the research by completing the anonymous questionnaire. Overall, Version 1 included 6 pages with fill-it-in or tick box response categories and the final page asked five open-ended questions.

Demographic data. This section of the survey sought basic information from respondents including age and gender. Participant data for both 2012 and 2013 versions of the survey are presented in Table 2. We also include data for the year cohort and the general Australian population (Commonwealth of Australia, 2012) for comparison purposes. Table 2 shows that survey respondents in the Under-19 category were under-represented in the sample, as compared to the distributions for the entire cohort and the general Australian population. The 19-25 year-old category may also be under-represented in the sample, although to a lesser extent.

Table 2

2012 and 2013 Participant Age Range and Gender Data Summary

Age (yrs)	<19	19-25	26-35	>35	Totals (%)
2012 (%)	35(29)	68(57)	12(10)	4(3)	119(100)
Female	28	56	8	4	96(81)
Male	6	12	4	0	23(19)
2012 Full Cohort (%)	99 (43)	10(45)	21(10)	5(2)	232(100)
Female	83	87	16	4	189(82)
Male	16	18	8	1	43(19)
2013(%)	25(16)	123(77)	9(6)	4(3)	161(100)
Female	25	124	6	4	131(81)
Male	0	27	3	0	30(19)
2013 Full Cohort (%)	103(41)	121(49)	20(80)	5(2)	249(100)
Female	87	92	14	3	196(79)
Male	16	29	6	2	53(21)
Australia[1] (%)	116 (39)	131 (44)	27 (9)	24 (8)	300 (100)
Female[2]					169(56)
Male					131 (44)

Note 1: 012 census data, expressed in thousands (Commonwealth of Australia, 2012).
Note 2: 2012 census data does not include gender breakdown across age groups.

Connecting to the internet. Respondents were asked to indicate which devices they use to connect to the internet. Responses were indicated with a 'tick' in a box beside the named device and yes or no responses were coded numerically (0=no; 1=yes). Data are presented in Table 3 below.

Table 3

Numbers of participants and ways they connect to the internet

	2012 data (N=119)	2013 data (N=161)
Device	**%**	**%**
Smartphone	82	95
Laptop computer	93	96
Campus computer	52	62
Desktop/home computer	50	50
iPod	31	16
iPad/tablet	26	37
Other	3	n/a

Note: Numbers sum to over 100% due to multiple devices reported by some individuals

Proficiency with social media. In each of the three main sections of the survey, the first question asked respondents: "For each social media application listed below indicate what kind of user you are." Section A specified "in your everyday life**."** Section B specified "when you are using the application to support your science learning in [EDKS, e.g. science subject]" and Section C specified learning in "your high school science classes." Proficiency of use was indicated by ticking a box to choose among the following categories:

Non-user: Never heard of it or never used it.

Novice: I've used it once or twice

Competent: I've got an account and I use it mostly to read content.

Proficient: I frequently use this application to both read content and to contribute content.

Each of the three sections included the same table with items and response choices in columns to indicate proficiency level, which provided data that compared an individual's social media proficiency across three places where such tools were used: everyday use; university science; and high school science.

Data for the 2012 cohort are presented in the top half of Table 4. To enable comparisons of the extent to which students used the tools, the response categories were assigned a numerical value (0= non-user; 1=novice; 2=competent; 3=proficient) and means and standard deviations were calculated for each social media application as a measure of how proficient students felt themselves to be with social media tools on a range of non-user (0) to proficient (3).

Table 4

Social Media Proficiency Data Summary: Use in Everyday, University and High School Contexts

2012 Data	Everyday use			Univ science use			High Sch sci use		
	Prof/ Comp	mean	SD	Prof/ Comp	mean	SD	Prof/ Comp	mean	SD
Social networking	98%	2.75	0.51	59%	1.75	1.14	41%	1.21	1.28
Communications	47%	1.41	1.00	18%	0.54	1.00	31%	0.93	1.13
Blogs	19%	0.72	0.11	7%	0.20	0.61	4%	0.13	0.43
Microblogs	14%	0.56	0.96	4%	0.13	0.48	<1%	0.05	0.26
Document mgmt	34%	1.10	1.10	22%	0.66	1.07	7%	0.25	0.64
Soc bookmarking	7%	0.27	0.66	6%	0.17	0.54	<1%	0.05	0.26
Social news	9%	0.37	0.75	3%	0.13	0.46	3%	0.09	0.37
Wikis	57%	1.63	0.93	19%	0.93	0.99	52%	1.38	1.13
Videosharing	78%	2.07	0.88	47%	1.39	1.12	34%	0.93	1.13
Livecast	51%	1.49	1.16	11%	0.32	0.79	9%	0.25	0.69
Music sharing	24%	0.80	1.01	5%	0.18	0.53	3%	0.12	0.44
Photo sharing	21%	0.74	1.03	7%	0.24	0.65	3%	0.12	0.48
Discussion forum	32%	1.06	0.99	16%	0.50	0.85	20%	0.53	0.95
Learning Mgmt Sys	n/a	n/a	n/a	38%	1.08	1.24	7%	0.20	0.65

2013 Data	Everyday use			Univ science use			High Sch sci use		
	Prof/ Comp	mean	SD	Prof/ Comp	mean	SD	Prof/ Comp	mean	SD
Social networking	91%	2.39	0.49	75%	2.04	0.57	44%	1.27	1.13
Communications	92%	2.47	0.75	76%	2.06	0.99	58%	1.61	1.04
Blogs	11%	0.53	0.68	1%	0.09	0.36	2%	0.14	0.47
Microblogs	6%	0.32	0.81	1%	0.08	0.35	2%	0.14	0.43
Document mgmt	34%	1.12	0.70	33%	0.93	1.14	12%	0.36	0.79
Soc bookmarking	4%	0.14	1.01	3%	0.09	0.44	3%	0.13	0.43
Social news	11%	0.44	0.47	4%	0.12	0.48	1%	0.10	0.38
Wikis	45%	1.34	0.74	24%	0.85	0.88	47%	1.17	1.02
Videosharing	70%	1.76	0.81	58%	1.53	0.97	22%	0.66	0.91
Livecast	25%	1.01	0.80	2%	0.13	0.42	3%	0.13	0.46
Music sharing	20%	0.65	0.88	5%	0.19	0.58	3%	0.14	0.46
Photo sharing	25%	0.86	10.87	10%	0.31	0.69	4%	0.15	0.51
Discussion forum	9%	0.55	1.07	12%	0.45	0.78	11%	0.40	0.71
Learning Mgmt Sys	n/a	n/a	n/a	24%	0.67	1.03	3%	0.16	0.56

Social media learning behaviors. The survey includes two corresponding sections regarding social media learning behaviors in university science classes (Section B) and high school science classes (Section C). Each of the sections includes three parts, with sample items and response choices:

Part 1. *Frequency of use of social media for particular kinds of science learning behaviors*. Sample items: "Use Facebook chat (or MSN or texting) to contact a friend to get help with class assignment," "Search YouTube for a video to learn about a science concept." Response choices: Never, Sometimes, Regularly. (see Table 5.1)

Part 2. *Frequency of online science learning behaviors*. Sample items: "When completing EDKS homework I work in front of my computer so that I can search the Internet and/or Google," "When I find a good science online resource I bookmark it or save it somewhere so that I can access it later."
Response choices: Never, Sometimes, Regularly. (see Table 5.2)

Part 3. *Responses to being 'stuck' on a science problem*. Sample items: "Text a friend," "Go to a website directly where I think the answer might be."
Response choice: "Yes I do this." Respondents were also asked to rank their Top 3 choices. (See Table 5.3)

Respondents completed each Part for both university and high school contexts, which potentially enables some developmental comparisons between high school and university. For Parts 1 and 2 the response categories were assigned a numerical value (0=never; 1=sometimes; 2=regularly) and means and standard deviations were calculated for each item as a measure of how frequently students engaged in the social media learning behaviour with a range of never (0) to regularly (2). We treated this as a continuous variable. Part 3 aimed to explore what science learners do when stuck on a problem or assignment, asking them to indicate whether they had done the particular behaviour and then rank their 'Top 3.' Through this ranking, we gather preferences for resources learners use when they face challenges in their learning activity. Data for these survey Parts are presented in Table 5.

Table 5

Social Media for Science Learning Data Summary: Use in University (Section B) and High School Contexts (Section C)

5.1 Frequency of social media use for learning science (Q B5 +C5)

5.2 Social media behaviors (Q B6 + C6)

5.3 What do you do when stuck on a task? (Q B7 + C7)

5.1 Frequency of social media use[1]	2012 (B5) EDKS Freq		2013 (B5) EDKS Freq		2012 (C5) HS Freq		2013 (C5) HS Freq	
	mean	SD	mean	SD	mean	SD	mean	SD
FB chat, MSN or text a friend	1.31	0.69	1.59	0.60	0.97	0.83	1.12	0.81
Skype to connect with friend or group	0.13	0.40	0.03	0.16	0.12	0.37	0.07	0.27
Ask a Q on an online forum	0.31	0.59	0.22	0.46	0.27	0.54	0.14	0.39
Collaborate via online document tool	0.29	0.54	0.53	0.71	0.13	0.33	0.25	0.53
Join a FB group to share HW, links	1.17	0.75	1.65	0.65	0.32	0.61	0.45	0.74
Search for videos to learn science	1.15	0.67	1.40	0.65	0.59	0.69	0.68	0.74
Wikipedia to search for content	0.84	0.69	0.94	0.76	0.89	0.76	0.92	0.78
Answer or comment on science forum	0.14	0.40	0.15	0.41	0.17	0.43	0.09	0.35
Read a blog or news	0.45	0.62	0.57	0.59	0.20	0.46	0.26	0.49
Follow scientists or science feeds	0.06	0.27	0.01	0.11	0.05	0.26	0.05	0.29
Save/share on social bookmarking site	0.08	0.36	0.09	0.28	0.09	0.32	0.07	0.27
Post content on a blog	0.03	0.18	0.15	0.42	0.05	0.26	0.05	0.24
Store apps on smartphone for sci learning	0.15	0.41	0.20	0.43	0.08	0.31	0.10	0.32
Share/post videos related to sci learning	n/a	n/a	0.14	0.38	n/a	n/a	no data	

[1] Response choices for Tables 5.1 and 5.2: 0 = never; 1 = sometimes; 2 = regularly

5.2 Social media behaviors	2012 (B6) EDKS Freq		2013 (B6) EDKS Freq		2012 (C6) HS Freq		2013 (C6) HS Freq	
	mean	SD	mean	SD	mean	SD	mean	SD
Doing HW, computer on to chat if stuck	0.96	0.72	1.18	0.73	0.96	0.78	1.06	0.82
Doing HW, computer on to search internet	1.73	0.50	1.84	0.40	1.38	0.73	1.49	0.64
Seek answer to particular problem	1.20	0.67	1.21	0.67	1.25	0.68	1.38	0.69
Search for info to understand concepts	1.57	0.56	1.68	0.49	1.22	0.73	1.26	0.73
Search for resources for sci learning	1.35	0.68	1.50	0.59	0.91	0.82	1.03	0.81
Bookmark good resources	1.18	0.74	1.28	0.73	0.60	0.73	0.65	0.74
Use tools to collaborate on HW	0.28	0.55	0.57	0.73	0.15	0.38	0.26	0.55
Share resources with classmates	0.50	0.66	0.81	0.64	0.22	0.46	0.26	0.51

5.3 What do you do when stuck?	2012 (B7) EDKS (n=119)		2013 (B7) EDKS (n= 161)		2012 (C7) HS (n=119)		2013 (C7) HS (n=161)	
	Yes	No	Yes	No	Yes	No	Yes	No
Look for an example in text	101	17	100	25	95	11	29	118
Text a friend	111	18	90	17	75	31	70	21
Chat with a friend online	81	38	84	24	67	39	82	40
Do a google search	117	1	53	2	97	9	78	49
Go to website that might have answer	75	44	79	46	59	47	78	53
Read or post to online forum	41	78	70	83	35	71	48	100
Look for video to teach me	83	36	99	33	43	63	65	74
Phone a friend	56	63	68	70	54	52	59	73
Email a friend	70	49	83	59	34	72	54	95
Organize a study group	30	89	66	81	22	84	45	100
Ask an instructor	n/a	n/a	96	39	n/a	n/a	70	38

Open-ended questions. Section D of the survey includes questions that explore respondents' practices for social media and science learning practices more generally. Questions included:

1. What is the biggest benefit to having access to the internet for learning science?
2. What is the one online or social media application that you could not live without while studying science?
3. Has the way you've used social media or online resources to support your science learning changed from the way you used them in high school to the way you use them now? If so, how?
4. Are there differences in the way you use social media to support your science learning when compared to how you use social media to support your learning in other subject areas? If so, what are the differences?
5. Did any of your high school science teachers or university science classes use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

The open-ended questions enabled a more qualitative exploration of respondents' social media practices, where analysis could be conducted thematically or for specific evaluative purposes within a given science learning context. For example, 55 respondents indicated Google and 33 others indicated Facebook in response to Question 2 ("Which application could you not live without"). Further, the open-ended questions enabled an internal validity check for this early version of the survey.

Synthesis. This section has presented the structure of the *Social Media and Science Learning Survey*. The survey items were derived from focus group interviews with a range of science learners and the first version of the survey provided evidence for our earlier assertion that a survey could provide important background information about how science learners use social media applications to learn science. The next step in the development process involved validation interviews with a sample of survey respondents for the express purpose of clarifying survey items and iteratively refining the survey.

Inductive Validation of Survey and Revisions to Generate Version 2 (2013)

We invited 2012 survey respondents to participate in feedback interviews. The interviews (n=4) were conducted after the semester was finalized, lasted about 30 minutes and were audio-recorded. Pseudonyms are used throughout. Our aim in conducting these interviews was to assess

several aspects of the survey from the perspectives of the respondents. We sought perspectives on clarity of items and the structure of the survey, including wording for instructions and items, formatting and overall length. To analyse interview data, we gathered all answers to interview questions in a response matrix, which we used to compare and contrast the range and depth of responses to interview questions.

An important content validity question was: "What is your working definition of social media?" This question allowed a cross-check with the stated definition given in the introduction to the survey. In the interviews, we wanted to consider if responses were based on a common definition consistent with our intention to identify social media applications and learning behaviors for science learning.

Another question asked how carefully the respondent read the introduction and the instructions for each section. Half of the interviewees indicated they read the introduction carefully, while the other half "skimmed" over it. While the instructions for sections were similar, there were key differences regarding the context for social media use (everyday, university science, high school science). All but one of the interviewees noted that they carefully read these instructions, as Gayle indicated, "because I don't feel like I can answer things if I don't actually know what it's about." The fourth student (Tannis) admitted to skimming over both the introduction and the instructions.

There were additional internal consistency checks conducted through the interviews, such as the general interview question: "Was it clear that the sections of the survey deal with different areas of your life where you may have used social media?" Through further probing questions, we realized that there were confusions possible among the three sections if the instructions were not followed, and this alerted us to the need for clarification in the next iteration of the survey.

We also asked if the information being requested in each section, including the open-ended questions, was clearly worded. Interviewees were asked to restate a sample of survey items for the express purpose of assuring us that the questions were interpreted as intended. For example, Survey Item B5 asks: "Please indicate how you use social media to support your science learning in EDKS in the following ways: [a number of ways are listed as choices]" The item includes a range of social media learning behaviors and asks respondents to indicate frequency of use. While referring to a hard copy of the survey, Gayle echoes other interviewees in explaining the item: "So this was specific. It wasn't just whether you used it; it was how you used it as well." By asking interviewees to explain their interpretation of what the survey items were asking, we could be confident that the questions were worded appropriately and assessed the relevant content area, thus establishing a reasonable degree of content validity.

Interviewees were also explicitly asked about wording changes that might make particular items more clear. Kasey noted that items in Question B6 gave some context to a particular kind of learning behaviour, however, in some cases, too particularly. For example, the item "Use tools such as Google docs or a wiki to collaborate with my friends" could be interpreted too narrowly as using only the named tools according to Kasey: "some people may think that you're only talking about those tools" rather than the wider context of using *any* online tool that supports collaboration.

Along with questions to establish wording clarity and interpretations, interviewees were asked about their familiarity with the listed social media applications or learning behaviours. Consistent with survey data in Tables 4 and 5 (proficiency data and social media behaviours), there were many applications that the 2012 survey respondents either didn't know about or didn't use. Interview data confirmed this as noted by Kasey: "I didn't know 'livecasting'…I know Delicious and Reddit but I don't know exactly really what they do."

A key area for the interviews was the clarification of respondent interpretations of the response choices. This is especially salient for questions A4, B4 and C4 that asked about user proficiency and items such as B5 and B6 asking about frequency of use. Proficiency was categorized as non-user; novice; competent; or proficient on Version 1 of the survey. Consistent interpretation of the response choices is fundamental to establish that the choices represent a continuous scale that justifies conversion of the response choices to numeric values for later statistical work. In the interviews, we asked each participant to comment on the ease with which they could consistently apply the scales across the survey sections. Thus, while the same proficiency scale was used across three sections (everyday use, university science and high school science), interviewees admitted to struggling. Gayle commented: "I found it particularly hard with the high school. Thinking back, social media wasn't something that we really used" while Tannis said, "I think I had problems with one section because I didn't understand…I didn't know some of them." While basic knowledge of the application is prerequisite to reporting one's proficiency, the scales may have confused the matter. Thus, we asked a follow-up question to assess the interviewee's ability to distinguish between "competent" and "proficient." Keeping in mind that the instructions for each section explicitly defined the scale terms, the interviewees commonly used their own definitions that were typically based on personal background knowledge:

Kasey: "Competent depends on what I'm doing…I didn't know how to use it for science learning. It depends on how much I actually use it for that question."

Tannis: "I just thought, am I good at it? Or, do I use it often enough to actually be able

> to use it without thinking? 'Competent' I'd be able to do it well but not really well if that makes sense. But I can do it and I do it without too much difficulty, but 'proficient' I could definitely do and do it on a regular basis."

These interview comments suggested that the scales were likely interpreted differently among the respondents and as compared to the definitions given in the section instructions. The definitions were also possibly conflated with frequency of use, which indicated a need to reconsider the scales.

Survey Version 2 (2013)

Based on interview analysis and further analysis of survey data (Nielsen et al., 2013), we concluded that the survey was gathering the kinds of information that we intended. However, key findings from the interviews indicated problems with instructions in some sections; possible misinterpretations of response choices; some of the listed social media tools were unfamiliar to respondents; and the initial survey was likely too long. Based on these findings, we focused on two categories of changes to inform the next iteration of the survey: changes for clarity and structural changes.

Changes for clarity. Instructions were typically intuited rather than followed explicitly, according to our analysis of interview comments. This was a concern for consistent interpretation of terms by survey respondents, which led to minor revisions to item wording and response scales. Some of the items referred explicitly to websites or social media applications. The intention in these items was to understand the behaviour in using a *type* of application (rather than the particular website or application). This is a similar issue for other items in Sections A, B and C where specific applications are named. As a result, items referring to a specific example were examined and rephrased. This rephrasing provided more detail about the type of behaviour that the question is aiming to understand and thus shifts the emphasis slightly from the type of application to the behaviour. Further, interviewees had commented that offering examples of the applications was important in providing context for the use.

We acknowledge that some of the application types referenced on the survey were unfamiliar to our participants. This may limit applicability or relevance of a general survey such as this one, however, the applications were identified in the initial focus groups among social media users and thus represent a wide range of use, which is the underlying intention for the survey.

We adjusted phrasing for instructions or items based on feedback from interview respondents and the need to ensure the ability to handle the data statistically. Noting that response choices for items regarding the type of user in Items A4, B4 and C4 were variously interpreted by interviewees, these respondents typically seemed to equate intensity and duration of use with effort rather than respond to the item based on the kind of user behaviour as specified in the definitions. The questions aimed to probe the *type of user* for each of the applications listed. Thus, to emphasize the different levels of frequency of use, response choices for items in A4, B4 and C4 were changed to: *non-user; infrequent user; frequent user;* and *contributor* in the next version of the survey according to the following definitions:

non-user: Never heard of it or never used it.

infrequent user: I use it sometimes.

frequent user: I use it regularly.

contributor: I frequently use this application to both read content and to contribute content.

Questions B4 and C4 also asked respondents to "Explain how you've used it" when indicating the type of user on the listed social media applications. We rephrased this instruction to reinforce the context for the application's use in the column heading to now read: "Explain how you've used it in EDKS" (B4) or "Explain how you used it in high school science" (C4). Any explanations provided in the open-ended prompt 'other' at the end of these questions were handled as string variables, although like other parts of the survey where free responses were solicited, very few respondents offered explanations.

Other questions were worded in a way that created problems for statistical analyses. Questions B7 and C7 asked respondents to indicate "Yes I would do this" and "Rank your Top 3" resources used most when stuck on a problem or task. These questions were exploring actual help-seeking behaviour in either university (B7) or high school (C7) science learning contexts, so the response choices were reworded. The first column was changed to ask the respondent to make a mark: "Yes I have done this" and further, indicate the "Most frequently used resource."

Structural Changes. Structural changes were warranted for several reasons including ease of statistical analyses and the need to shorten the survey. In the opening demographic section of the survey, we asked respondents to indicate their age according to age ranges from the Australian Census categories. We had believed this would provide various comparison points, for example among high school and university-aged students. However, we lost specificity with the original age range categories (that also overlapped) and with the significant changes to access and use of social media

among different age groups, felt justified in adjusting the survey item to ask for the respondent's actual age. With the change, groups can still be aggregated according to census categories allowing for a breadth of other sorts of analyses.

Several survey items provided the opportunity for respondents to indicate 'other' when noting the frequency of use for particular kinds of social media applications or learning behaviours. We noted that in most cases, no respondents offered responses in this category. This justified deleting the 'other' choice but also alerted us to attend to other open-ended or string items where write-in responses were requested. In cases where there were few if any responses or if the responses duplicated other parts of the survey, the item was deleted. For example, responses to open-ended Item D4 ("Are there differences between how you use social media in science compared to other subjects?") provided no new information regarding social media use for science. Rather, responses duplicated information in other areas of the survey or indicated no differences. Of the 119 surveys returned, 104 indicated "no" or "not really" while 12 others said that they used social media applications the same way in all subjects. Only four respondents said that they used social media applications more for science while three others said they asked friends for help more often in science. From these results, we concluded that the question could be deleted, and with a growing concern that the survey may be too long, we also examined the survey hard copies for signs of 'survey fatigue.' Deleting the 'other' choices and an open-ended question resulted in a minor shortening of the overall length of the survey.

Piloting Revised Survey Version 2

The survey was revised according to analysis of the interviews and our further analysis of the completed surveys, including statistical analysis of the data set. The revised survey was then piloted with a new group of EDKS students in 2013. This participant group included 161 preservice teachers (131 female, 30 male) who volunteered to complete the survey. We conducted similar analyses of the survey data in 2013, which are presented beside 2012 data in Tables 2, 3, 4 and 5.

Descriptive statistics from the two years of surveys provide a breakdown of age and gender across the samples. These data indicated some differences in distribution across the two sample populations, in particular there was a smaller portion of Under-19 and higher portion of 19-25 among the 2013 sample. However, the gender distributions were very similar to the full-cohort distributions for the two samples. Similar to the 2012 sample, the Under-19 group of participants were under-represented relative to the entire cohort and the Australian population (Commonwealth of Australia, 2012). Anecdotally, we noted that this population of first year university students typically do not attend 830am lectures, and thus it is likely that many were not present during survey administration.

Validation Interviews for Revised Survey Version 2

Follow-up validation interviews after the 2013 survey administration were conducted with volunteering students (n=6) in order to evaluate the changes made to create Survey Version 2. Data were handled similarly to the first validation interviews including gathering all responses into a response matrix. To finalize the survey, this section focuses on the key issues of phrasing for items and instructions and response choices for proficiency with social media. As in the initial validation interviews in 2012, we asked 2013 participants to interpret the instructions and items. We were concerned that the instructions were simple to follow as well as consistent across the survey sections. Thus we asked interviewees if they read the instructions carefully. Most did: "Oh, I read everything for it," but two others noted, "I would say I would have just read over the main points" and "not very carefully. I just looked at the key words." While we might like all survey respondents to carefully read the instructions, if they picked up the main points, we can be satisfied that the instructions were suitably clear. We also asked about item interpretations for items that were rephrased in Version 2, and were satisfied that language shifts to emphasize learning behaviour rather than a particular social media tool were acceptable. For example, interview respondents were uncertain about the term 'micro-blogging'. However, all participants knew about Twitter, hence, each of the social media tools listed now includes a very familiar example, as suggested by interviewees.

Interviewees also noted that the sections seemed repetitive, particularly the instructions. In our analysis, we note that this is positive, since the instructions are the same across the three contexts, and thus, likely to be interpreted consistently even if intuitively or according to the main ideas.

Perhaps the largest difference in Survey Version 2 is the change to the response categories for A4, B4 and C4. While our aim was to gauge the survey respondents' proficiency of use according to the type of user with the range of social media applications, the scales used in Version 1 were more indicative of their frequency of use. Combined with the tendency to intuit rather than follow section instructions, we revised the scales for these sections to more explicitly capture frequency of use. The terms used as response choices (non-user, infrequent user, frequent user, contributor) also offer a way to interpret type of user, independent of definitions for response choices.

Discussion

With refinements to the survey following two cycles of development and validation interviews, we present a survey tool that can capture how science learners use social media tools to learn science.

In this section, we discuss the various measures taken in order to validate the survey including three types of validity: credibility, reliability and transferability.

Credibility. Credibility of the survey was established in several ways. Survey items about social media behaviors were chosen because they emerged from interviews from users of social media. Thus we can be confident that the questions we were asking are relevant to the goal and purpose of the survey – to understand science learners' social media learning behaviors. We can ask "Do the findings capture what is really there? Are investigators observing or measuring what they think they are measuring?" (Merriam, 2014, p. 213). Gathering and sorting the various uses of social media tools on the survey reflects a version of reality that can be believed, having been gathered and affirmed through multiple data sources including focus groups, survey versions and follow-up interviews. The threat to this kind of validity could be that other readers of the question interpreted something about the question differently. To deal with the issue of item interpretation, we conducted two cycles of validation interviews in the current research, each of which involved 4-6 individuals after each administration of the survey. We conducted "respondent validation" (Maxwell, 2005, p. 111), which is similar to member checking, but aimed specifically at testing the wording of instructions and items in the survey with the interview participants (who had previously taken the survey). We sought these respondents' interpretations of what they were being asked to do or what the question or item was asking in order to interpret if their responses were consistent with our intentions for the question being asked. By rephrasing and testing the wording in the instructions and questions, we have established that the respondents could accurately identify the kinds of social media tools they used and characterize themselves as a type of user for that tool, which are key aims of the survey.

Reliability. Reliability (or dependability and consistency) is the notion that a construct is static and can be measured in the same way with the same results at some time in the future. In other words, can the methods be repeated and achieve the same results? This basic assumption about the construct of reliability is based in a conception of reality that does not fit well with the underlying theoretical framework driving our research. From a complexity perspective, knowing is subjective (Davis, Sumara & Luce-Kapler, 2007), even across an individual. Thus, the notion of reliability as a construct needs to be challenged for a social behaviour such as social media use, because it is not static: it is essentially tool-use that resides in a context, that may well change over time for both individuals and for groups of individuals. However, in the current study, we have 'measured' social media use among two year-groups of first-year Bachelor of Education students and even though there are some subtle differences between the respondent samples, the analyses demonstrated that the two groups performed similarly on the survey versions and validation interviews. Further, the distribution of survey participants according

to age and gender was similar to the full cohort population in each year of survey piloting, lending an acceptable degree of consistency and dependability in terms of the data collected.

Transferability. In the traditions of qualitative research, it is problematic to generalize findings across a wide range of other contexts. We use Cronbach's (1975) notion of 'working hypotheses' to think of qualitative findings that reflect the situation or context where they were developed and in reporting the research; it is important to offer adequate description of the participants and the context so that others may judge the adequacy and the relevancy of the results to their own context. By inductively developing the content of the survey with a range of physics learners through focus groups in two countries and trialing the survey across two iterations with preservice teacher education students in a third country, we have, in a way, achieved 'maximum variation.' Across these science learning contexts in different countries, our participants range in age from 15 or 16 to some in their early 40s. We thus have confidence that the range of social media tools these diverse learners identified *could* represent many other contexts and uses for social media tools in science learning. However, to be more widely representative of social media use in other science learning contexts, the survey will need to be administered in a range of other contexts: this is how the results of the process of survey development becomes transferable. With our aim to understand how science students use social media tools to learn science, the survey provides a snapshot for how a group of students use social media tools to learn the science in their contexts. We leave it up to readers to determine how useful this survey is for them in the contexts in which they work.

Conclusion and Implications

Developing and validating the *Social Media and Science Learning Survey* enables wide-scale administration of the survey that will provide important background information to enable comparisons over time and across contexts. Our ultimate goal is to understand how social media tools can be leveraged in order to allow learning to emerge and to use this knowledge to frame recommendations and methods for integrating these tools into classroom based environments. As educators, our ability to integrate the use of social media tools into our classrooms will enable our students to more fully utilize and benefit from the connectedness, and thus learning potential, that social media tools can provide. Further, engaging students to use personal technologies will be of increasing importance as districts and ministries of education strive to meet calls for 21st century learning across school and university contexts.

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