Connected Biology: A Usability Study of Web 2.0 Tools

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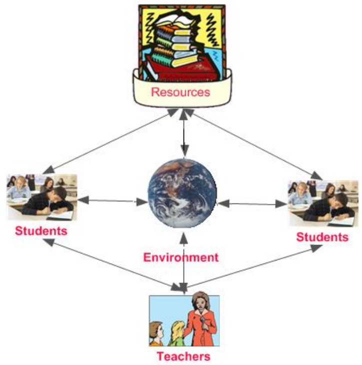
Popularized Article for PAREA Project *PA2010-012*

Introduction



The term, **Web 2.0** tools describes tools embedded in web sites that facilitate interactions among students, teachers, resources, and the environment in an on-line environment. The term was first coined by Darcy DiNucci in 1999 but popularized by Tim O'Reilly and Dale Dougherty in late 2004. Over the last decade there has been an exponential increase in the use of these tools (blogs, wiki's, twitters, YouTube, etc.) from 0 to the billions. Alternative terms include social media, social networking sites, technology-enhanced learning (TEL), interactive web, etc. Two features of these tools are that they shift the user (in this case student and teacher) from consumer to creator and that the resources are open to the world not only to the class. This is in contrast to Web 1.0 tools which supported a "broadcast" model of teaching in which the teacher controlled the content and access, and in which discussion was limited to those in the cohort.

For the last decade, annotated lists of web 2.0 tools have been published encouraging teachers to make use of these tools. Since 2007 Larry Ferlazzo has published the best web 2.0 tools of the year (see http://larryferlazzo.edublogs.org/). Other educational repositories include http://edtechtoolbox.blogspot.ca/p/web-20-tools_04.html, http://edjudo.com/web-2-0-teaching-tools-links, http://web2014.discoveryeducation.com/web20tools.cfm, http://www.edudemic.com/best-web-tools/, and http://oedb.org/ilibrarian/101-web-20-teaching-tools/ to name only a few. Bower (2015) published a typology of 212 web 2.0 tools suitable for educational purposes. He identified 37 types of Web 2.0 tools forming 14 clusters.

Subsequently, there have been many articles reviewing the use of web 2.0 tools in post-secondary. These are only briefly described in this paper. A more thorough description is given in the final report (d'Apollonia, Kunicki, and Bronet, 2015).

Use of web 2.0 tools in post-secondary education

Blended learning environments in which on-line resources (especially open educational resources) support traditional lecture classes are now becoming the norm in many post-secondary institutions around the world (Zawacki-Richter, et.al., 2015; Gideon, Capretz, Mead, and Grosch, 2014. Thus, researchers have begun to investigate the use of Web 2.0 technologies in post-secondary institutions using both literature reviews and surveys. Campión, Nalda, and Rivilla (2012) developed a tool to investigate the Web 2.0 use by 402 instructors at the National University of Distance Education in Spain. They reported that although instructors understand that Web 2.0 applications can be effective in fostering learning, few actually use them. Those that do so use them as a means of consuming knowledge not creating knowledge.

Gideon, Capretz, Mead, and Grosch (2014) administered a 150 item questionnaire to 985 students and 210 instructors at Western University in 2013. Students reported that they attended lectures and then studied at home using computers but they did this alone, not by collaborating with other students on-line. They also frequently searched the internet for learning materials. On the other hand, instructors frequently used the internet to search for teaching and learning materials. They also collaborated more frequently than did students. Students and instructors used such e-learning applications as video sharing, recording software (for lectures), and on-line self-tests moderately. They primarily used traditional media in lecture-based courses, rarely using Web 2.0 applications (other than Google). Thus, although Web 2.0 tools are readily available, instructors at universities have been slow to adopt them for their courses (Tess, 2013).

Several researchers (Strawbridge, 2010; Conole & Alevizou, 2010) have described how pedagogical perspectives and approaches influence the appropriateness of technology use. For example the *Associative Perspective* (behaviorism, instructional design, didactic, intelligent tutoring) is prescriptive (transmissive) and focuses on controlled and adaptive responses and observable outcomes. The *Cognitive Perspective* (problem-based learning, inquiry-learning, discovery-learning) is task oriented and focuses on self-directed activities in which language is a tool for the co-construction of knowledge. The *Situative Perspective* (cognitive apprenticeship, collaborative learning, social constructivism) is socio-culturally contextual and focuses on participation within a community. Clearly, Web 2.0 tools can greatly enhance classroom practices based on the *Cognitive* and *Associative Perspectives*. However, some researchers have argued that Web 2.0 tools are inappropriate in classroom practices which focus on teacher-directed systematic guidance towards prescribed goals. Conole and Alevizou (2010) argue that Web 2.0 tools can support associative pedagogies by providing modeling, timely feedback etc. Moreover, Williams, Karousou, and Mackness (2011) argue that both prescriptive and emergent learning are necessary in a learning ecology. The problem is how to balance the two somewhat contradictory approaches.

The effectiveness of web 2.0 tools

Hew (2013) reviewed 16 studies conducted in post-secondary classes which provided empirical evidence on the influence of podcasts, blogs, wiki's, twitter, and 3-D virtual worlds on student achievement. He reported that the evidence is still very weak that these technologies, *per se*, increased student achievement. In many cases, the students who used the Web 2.0 tools were given extra content, instructor support, and time on task. Nevertheless, none of the studies reported negative effects. It is worth noting that 50% of the studies used a transmissive pedagogy.

Three reviews, one of the dissertation literatures (Piotrowski, 2015) and two of published articles (Tess, 2013; Davis III, Deil-Amen, Rios-Aguilar, & Canché, 2014) came to the same conclusions. The majority of the studies were qualitative and collected data on affective outcomes. Results were mixed with generally positive effects on student engagement, effective communication, student satisfaction, and sense of community. Both reported that there were very few empirical studies on student achievement and in general these had methodological flaws.

A large study carried out with 9044 students enrolled in two Catalan universities (Castaño Muñoz, Duart, Sanch0-Vinuesa, 2014) concluded that the introduction of on-line activities to lecture classes significantly increases student achievement only if the on-line activities are interactive rather than transmissive.

Barriers to the Use of Web 2.0 Tools

Given that despite the availability of Web 2.0 tools, few post-secondary instructors incorporate them in their courses several researchers have investigated the barriers to their introduction. Canole and Alevizou (2010, p 20) state that "only a minority of enthusiastic teachers and those with a research interest in the learning science, educational technology or new media, have undertaken …exploration of the use of new technologies". They review several studies that investigated the barriers to the adoption of Web 2.0

technologies. These reports conclude that the three most salient barriers are the lack of appropriate incentives, the dominant culture of the teaching profession that does not value evidence-based educational research, and the lack of pedagogical imagination and training by most post-secondary faculty.

This has not changed much since 2010(Campión, Nalda, and Rivilla, 2012; Gideon, Capretz, Mead, and Grosch, 2014; Rogers-Estable, 2014). Several researchers have identified barriers to their adoption by post-secondary faculty. Rogers-Estable (2014) identified lack of training, lack of institutional support and lack of time as the three most common barriers. Additional reasons, provided by the faculty were "not structured into the curriculum, material, syllabus", "not appropriate to the context of the class", "would not improve learning". These later reasons provided by the instructors, emphasize that it may not be lack of technological expertise and motivation that is hindering the adoption of Web 2.0 tools; but, rather a conflict between the affordances of WEB 2.0 technologies and the deeply held beliefs of post-secondary faculty of what constitutes good teaching in their discipline (i.e., Associative Pedagogies).

Many teachers, realizing the importance of incorporating active-learning participatory technologies into their teaching practices, do make the attempt; however, many, if not most, ultimately fail to sustain their efforts (Messina, Reeve & Scardamalia, 2003). This has often been interpreted as a failure in their knowledge, effort, or available resources. However, an alternative interpretation is that features of the attempted implementation, *per se*, are at fault. That is, although the utility of the implementation is usually investigated, the usability of the implementation is not systematically tested. Usability in this context is the degree to which an implementation meets the needs of the users (both teachers and students) by being learnable, efficient, memorable, satisfying, and error-free (Usability Professionals Association, 2009). The goal of this paper is to investigate the usability of an implementation, herein called *Connected Biology*, incorporating Web 2.0 features in a College Biology course.

Intervention

The intervention, *Connected Biology*, consists of a web site which is accessed via a home page (https://place.dawsoncollege.qc.ca/~bionya) which includes a video, links to Science sites and an outline of the topics covered by the course. Each of the topics is linked to a topics page which includes the following elements: Pre-class Exercises (designed to prepare the students for the subsequent classes), Classes (designed to outline the activities done in class), Consolidation Exercises (designed to help students secure their learning), and the associated Learning Objectives (designed to guide students in their studying). The Web 2.0 tools associated with these elements are links to external sites, simulations, videos, images, a hot-linked glossary, on-line crossword puzzles, on-line concept mapping exercises, practice questions providing immediate feedback, links to on-line quizzes, and summaries of the topics. Classes were held in an Active Learning Classroom, containing 6 tables, each with a Smart board. There were 6 -7 students per table. In addition, students used a class conference on First Class (a collaboration platform) to access their teacher's materials and communicate with each other and their teacher. We collected data on 3 topics: Cell Structure, Cell Division, and Evolution. The goal of the web-site was to guide the students in preparing and review the course content so that they could engage productively in class. Work was assigned but not graded.

Participants

The participants were faculty and their students taking an introductory Biology course at Dawson College. The students were in the science program and taking their first college level biology course. Teachers were invited to participate in modifying and using *Connected Biology* in their courses. However, only one teacher agreed to implement Connected Biology in her classroom. Four other teachers agreed to be interviewed on their pedagogy and use of technology.

Students' Perceptions of the Usability of *Connected Biology*

A questionnaire, adapted from Lund (2001) was developed to survey students' perceptions of the usability of *Connected Biology*. The survey consisted of 20 questions (5-point scale), assessing 5 components of usability:

- Learnable: *Is it difficult to learn*?
- Error Free: *Do you make many errors using it*?
- Memorable: *Do you remember how to use it?*
- Efficient: *Does it help you get the job done"?*
- Satisfying: *Do you find it enjoyable and would you recommend it?*

Students were equally satisfied with *Connected Biology* over the three topics: Cell Structure, Cell Division, and Evolution. However, they perceived that *Connected Biology* was significantly less learnable, error-free, memorable, and efficient for Cell Division than for the other two topics. (see Table 1).

Table 1:Descriptive statistics (means and standard deviation) for students' perceptions of components of usability.

Usability Aspect	**Cell Structure (N=32)**		**Cell Division (N=31)**		**Evolution (N=32)**	
	mean	**sd**	**mean**	**sd**	**mean**	**sd**
Efficient	3.6	0.82	2.9	0.43	3.3	0.93
Error Free	3.4	0.64	3.1	0.49	3.7	0.68
Learnable	3.9	0.81	3.3	0.35	4.0	0.85
Memorable	3.9	0.84	3.1	0.28	4.1	0.94
Satisfying	3.3	0.75	3.6	0.34	3.6	0.87

There was a significant correlation ($t = .50$, $df = 30$, $p = .005$) between students' reported grades on their Cell Division post-test and their reported use of *Connected Biology*. Thus although students reported that Connected Biology was less learnable, error-free, memorable, and efficient for Cell Division, their achievement was positively associated with using the site.

How Did Students Actually Use *Connected Biology*

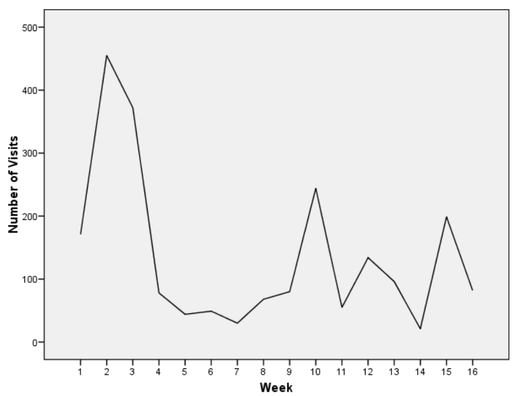
We used Crazy Egg (https://www.crazyegg.com), a commercial tracking service similar to Google Analytics to track the number of visits made by students as well as where they clicked and scrolled on the web pages. Crazy Egg provides several visualizations of how students used the website.

For example, the scroll map shows that students almost never scrolled to the resources at the bottom of the page: Science Daily, Ted Talks, BBC Science News, or Science Journal. On the other hand they scrolled to the middle of the page and accessed the topics. One reason for this behaviour may be that students were not given encouragement or grades by the teacher to visit these sites. We had expected that, as science students, they would be intrinsically motivated to explore the recommended science news links. However, students were focused on learning the content as quickly and efficiently as possible.

There are 10 visualizations of Confetti which show you where returning users and first time users are clicking, what day of the week students are visiting pages, what time of day students are visiting pages, what device students are using to visit web site, etc. For example, students accessed *Connected Biology* topics the night before the topic was covered in class (30% between midnight and 4:00 AM, 16% between 3:00 PM and 6:00 PM, 10% between 7:00 PM and 11:30 PM, and the rest in small numbers at other times).

You can also download the data for specific time periods in an excel spreadsheet and carry out statistical analyses.

We collected students' visits, clicks, and scrolls during the entire intervention of 16 weeks. Figure 2 illustrates the number of visits to the home page of *Connected Biology* during the intervention.

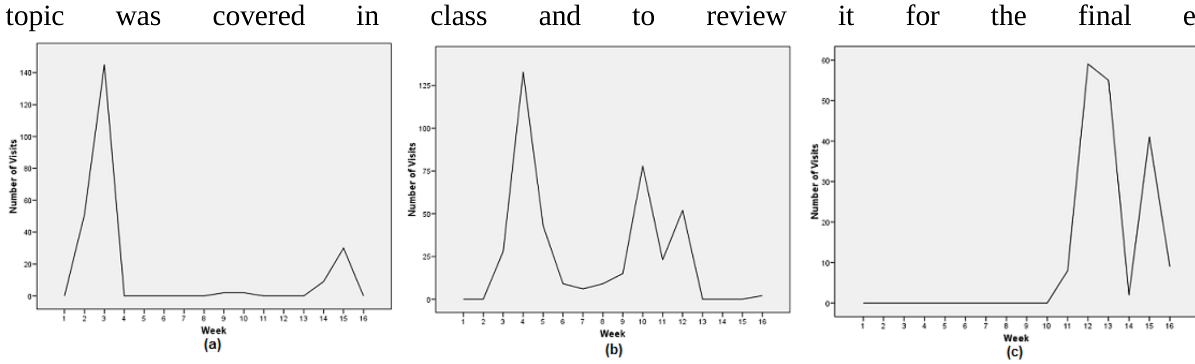


- Cell Structure was covered in weeks 1 and 2
- The first class test was given in week 3
- Cell Division was covered in weeks 4 and 5
- The second class test was given in week 10
- Evolution was covered in weeks 11 and 12
- The final exam was given in week 16

Figure 2. Number of visits to *Connected Biology* by week.

Students visited *Connected Biology* between weeks 2 and 3, on week 12, and on week 15. There appears to be a novelty effect, in that students visited *Connected Biology* in large numbers at the beginning of the intervention; but less so as the semester progressed. The data suggests that students began to visit *Connected Biology* to prepare for the final exam on week 12 but stopped visiting it on weeks 13 and 14 while they were preparing for their lab test and presentation of their research project (neither of which was covered by *Connected Biology)*.

Figure 3 shows the number of visits to each topic over the semester. Students visited Cell when the topic was covered in class and the week prior to the final exam. On the other hand, students visited Cell Division when the topic was covered in class and the week of the second class test. They also visited this topic on week 12, perhaps when they received the results of their second test after the Easter break (week 11). They did not visit this page to review prior to the final exam. Students visited Evolution when the topic was covered in class and to review it for the final exam.



<u>Figure 3</u>. Number of visits to Cell Structure (a), Cell Division (b) and Evolution (c) by week.

Students' accessed *Connected Biology* via a home page which listed each topic and linked to the topic pages for each unit. These topic pages included navigation links to preclass exercises, the classes, consolidation exercises, links to external tutorials, and activity frames with the objectives for each topic linked to an on-line glossary. Each element had several Web 2.0 tools (e.g., on-line practice tests, immediate feedback questions, images/videos/animations, internal and external web activities, on-line crossword puzzles, on-line concept mapping activities, etc.).

Table 2 shows the number and percentage of clicks to each element for each topic. The interactivity index (number of clicks/number of visits) for the Cell Structure, Cell Division, and Evolution units were 0.96, 0.84, and 1.37 respectively. This indicates that students were using the home page primarily to link to each topic. Once on the topics page they linked to the elements. The students were surprisingly consistent in their visits to the elements across topics. They primarily visited the pre-class and consolidation exercises and the objective/glossary. They rarely visited the linked tutorials (1.1%) which were featured on these pages. They also did not use the navigation buttons; but rather kept the pages opened and navigated by the tabs. Thus students were using *Connected Biology* primarily as an electronic study guide.

<u>Table 2: Number and student visits to *Connected Biology* elements.</u>

	Cell Structure		**Cell Division**		**Evolution**		**Total**	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Objective/Glossary	38	16	134	34.1	54	14.7	226	22.6
Link to Tutorials	6	2.5	2	0.5	3	0.8	11	1.1
Preclass Exercises	82	34.5	112	28.5	131	35.6	325	32.5
Classes	53	22.3	48	12.2	55	14.9	156	15.6
Consolidation Exercises	47	19.7	84	21.4	109	29.6	240	24.0
Navigation Buttons	12	5.0	13	3.3	16	4.3	41	4.1

Each of the above elements contained several Web 2.0 tools. We therefore analyzed how students used the Web 2.0 tools within each element.

How did students use the Objectives and Glossary Element

The interactivity indices (number of clicks/number of visits) for the Cell Structure, Cell Division, and Evolution were 0.1, 0.3, and 0.2, respectively. Students visited this element primarily to read the learning objectives; rarely clicking on the glossary terms (18%).

How did students use the Pre Class Exercises Element

Table 3 shows the number and percentage of clicks to each tool in the preclass element for each topic. The interactivity index (number of clicks/number of visits) for the Cell Structure, Cell Division, and Evolution units were 4.9, 7.7, and 12.2 respectively. Thus, students used this element to interact with the material. They also increased their interactivity over the span of the intervention. They were consistent in their use of the Web 2.0 tools, primarily using the Pre Class Exercises element to click on the immediate feedback questions (60.3%) and the summary of the topics (32.7%). They accessed the images, animations, and videos rarely (5.1%), and almost never accessed the suggested activities (1.2%).

Table 3: Number and percentage of clicks to Web 2.0 tools in the Pre Class Exercises element.

Tools	Cell Structure		Cell Division		Evolution		Total	
	N	%	N	%	N	%	N	%
Information	247	27.1	590	35.2	600	33.2	1437	32.7
Immediate Feedback Questions	598	65.6	884	52.7	1166	64.5	2648	60.3
Images/Animations/Videos	53	5.8	149	8.9	20	1.1	222	5.1
Activities	7	0.8	28	1.7	18	1.0	53	1.2
Navigation/Download buttons	7	0.8	25	1.5	3	0.2	35	0.2

How did students use the Class Element

Table 4 shows the number and percentage of clicks to each tool in the class element for each topic. The interactivity indeces (number of clicks/number of visits) for the Cell Structure, Cell Division, and Evolution units were 0.55, 1.8, and 0.43 respectively. Thus, students used this element primarily to read the page, perhaps to review what was done in class.

Table 4: Number and percentage of clicks to Web 2.0 tools in the Class element.

Tools	Cell Structure		Cell Division		Evolution		Total	
	N	%	N	%	N	%	N	%
Information	7	21.9	22	25.9	5	20	34	23.9
In-class Activity	13	40.6	61	71.8	14	56	88	62
Activity on External Site	11	34.4	0	0	5	20	16	11.3
Navigation/Download buttons	1	3.1	2	2.4	1	4	4	2.8

How did students use the Consolidation Exercises

The interactivity indeces (number of clicks/number of visits) for the Cell Structure, Cell Division, and Evolution units were 0.90, 0.80, and 0.65 respectively. Thus, students did not interact with this element. That is, they went to the page, read it, and left. Table 5 shows the number and percentage of visits that students made to the tools on the consolidation element of the three topics. Thus, students used this element primarily to do practice quizzes on the topics. They rarely accessed the tutorials, and almost never accessed the on-line crossword or on-line concept mapping tools.

Table 5: Number and percentage of clicks to Web 2.0 tools in the Consolidation Exercises element.

Tools	Cell Structure		Cell Division		Evolution		Total	
	N	%	N	%	N	%	N	%
Quizzes	91	98.9	116	93.5	7	100	214	96
On-line Crossword Puzzles	1	1.1	0	0	0	0	1	0.5
On-line Concept Map Tool	0	0	0	0	0	0	0	0
Link to Tutorials	0	0	8	6.5	0	0	8	3.5

What Are Teachers' Beliefs About the Usability of Digital Tools in the Classroom?

At the start of the project, several teachers agreed to consider using *Connected Biology*. However, when it was time to get the teachers and their students to formally sign the Consent Form; all but one teacher changed their minds. An additional teacher agreed to participate in a related intervention, *Connected Chemistry*. We therefore decided to interview the two teachers that participated as well as the three teachers that decided to not participate. Interviews with teachers were transcribed and coded into pre-existing categories that reflected the research interest: *digital tools used in course*, *desired digital tools*, *benefits of digital tools, barriers to the use of digital tools, beliefs about teaching and learning*

What digital tools were used in course

All teachers stated that they used the digital resource packaged with the text book. These included short videos (2), quizzes (2), and tutorials (1). Three teachers reported that they used you-tube videos. Two teachers reported that they used clickers, Smart Boards, external web-sites, teacher-created web-sites (the two participating teachers), and simulations (the two participating teachers). In addition one of the participating teachers reported using Google Docs and Google Spreadsheets. It is noteworthy that none of the teachers stated that they used a course management platform although all did. In addition none of the teachers that use First Class, a collaboration platform, mentioned it. This suggests that their use has become so internalized that teachers consider them as part of their normal teaching practices.

What are desired digital tools

There were very few responses to the question on what additional digital tools would they desire. Most responses had to do with improving the digital tools that they were already using. Two teachers stated that they would like additional Smart Boards, especially in the lab. Two teachers stated that they would like digital resource material (tutorials, quizzes) better integrated with what they teach rather than with the text book. One teacher responded that he/she would like clickers that allowed for short answer responses. One teacher responded that he/she would like to have student access to on-line journals.

What are the benefits of digital tools

The teachers all saw many benefits to the use of digital tools. The most frequent responses were increases students' engagement and interactions (3), allows you to monitor students' progress (3), allows you to provide immediate feedback (3), increased student understanding (3) and increases students' interest in content (2). The following responses were mentioned once: allows you to monitor students' contributions to group work, allows collaboration on data collection, allows students to pace their studying according to their individualized needs, encourages students to take responsibility for their learning, promotes more teacher collaboration, facilitates revising course materials, and results in better teaching.

What are the barriers to the use of digital tools

There were very few responses to the question on what were the barriers to the use of digital tools. The teachers were quite comfortable using technology and they all spend time preparing their courses. Three teachers responded that student access to the digital tools can be a barrier. Two teachers stated that they would like to have technical support when IT breaks down in the classroom. Two teachers responded that finding and evaluating the tools in the first place is a barrier. One teacher responded that the lack of collaboration within the department in developing and evaluating course specific tools was a barrier.

What are the beliefs about teaching and learning

Teacher A believes that students need to see the relevance of the class content to their lives. He/ she spends a lot of time and resources collecting videos and research papers (suitable for students) and uses them in class to initiate interest and discussion. Teacher A directs students to what sections of the textbook to cover and makes use of the on-line learning activities packaged with the textbook. However, he/she does not require students to do any of these activities because not all students have access.

Sometimes I bring in a YouTube documentary, but very short, and that starts the whole discussions. I think it gets them really stimulated when they see it. So I usually show them 5 minutes, and then that starts … a discussion on that topic.

Teacher B believes that it is important to put together a perfect course (notes, learning objectives, quizzes, etc.) and make them available to students at the beginning. He/she focuses on the course content and on "figuring out" what and how to deliver it. Teacher B directs students to what material they need to know, what readings they should do (that will not be covered in class) and gives them some practice questions. He/she believes there is not enough time to cover all the content in class.

I am still trying to put together the perfect course, to master the information that I want to present, and … how I want to present it. And have all of my course materials ready to go, learning objectives, practice questions and all that stuff.

Teacher C focuses on the text book and does not deviate from it. He/she uses the on-line materials (videos/activities/quizzes) packaged with the textbook in class because not all students have access to them. Teacher C allows students to bring their laptops to class and gives them questions/problems to discuss in small groups.

The textbook pretty much does [it] all, the online activity, it's because we mainly focus on the content of the textbook, so we don't really diverge ways from textbook. Like they can search on their own for some of our topics but I didn't encourage them.

Teacher D (a participating teacher) believes that students learn by doing and has designed activities for them to do in groups. He/she also believes that students need to be directed to the concepts they need to master, they need to come prepared to class, and need to consolidate their learning. Teacher D uses the teacher resources packaged with the textbook to design assessment questions at a higher cognitive level (analysis/synthesis). Teacher D focuses on how students are learning and what misconceptions they may have.

I've developed a lot of activities in class, educational activities, not just work sheets, but activities so that the students have to work together to do the research in the classroom to find, or discover the answer …. And then present it to the rest of the class.

Teacher E (a participating teacher) uses a suite of graded e-learning and problem-based learning activities which students complete as groups. He/she also uses a web-page that has instructional videos (from YouTube), practice questions, and the on-line materials packaged with the textbook to cover the course content.

We have a smart board [in the classroom] so I used that as a tool, and the way I used it, actually almost never pick up a real pen any more… so everything goes on the smart board, everything gets recorded, everything gets saved, everything gets then saved as a PDF, and everything gets posted for students to see. Then I created a … website for one of my courses, I have videos for theory, solutions, I have some assessment question and I have real questions, sort of quiz type questions, with objectives. And that's my whole course covering every major topic in the course.

Conclusions and implications

Although most students found *Connected Biology* satisfying, learnable, memorable, and error-free (but not efficient), they did not make much use of the embedded Web 2.0 tools. That is, they used the web-site as an electronic Study Guide. They used it when the topic was covered in class and prior to being tested on the content. They made little or no use of the enrichment tools (videos, activities, tutorials). Science students have a heavy workload, taking on average 3 science courses, a language course, a physical education course, a humanities course, and a complimentary course. They are very strategic in how they study. They made a great effort to complete the pre-class assignments, focusing on the acquisition of the content and testing their understanding. This had a positive effect on the class in that students came to class prepared. They were thus able to profit from the in-class activities and discussions. Thus, the prevalent student culture is: does the required work, participate in class, and prepare for tests. In other words they follow a prescriptive model (Williams, Karousou, & Mackness, 2011) of learning biology where learning is predictable albeit complicated, the organization of knowledge is hierarchal, verification and correction is provided by the teacher/experts and not negotiable. This view may in fact reflect the reality of formal post-secondary science education, at least at the introductory level. That is, in most science domains knowledge is "created and applied to give control" (Williams, Karousou, & Mackness, 2011, p 43).

The teacher interviews also reveal a teacher-centered pedagogy in which most teachers "stuck" closely to the textbook and associated materials. For example, a common course outline specifies the pages in the text book for which the students are responsible. All teachers, including the teachers that made use of Web 2.0 tools hold a prescriptive model of teaching. This may reflect both the nature of science (as taught at the introductory level) and the assessment practices. Unless work is graded, students do not do the work. However, "the traditional interpretation [of assessment] becomes problematic [in emergent learning networks]" (Romer, 2002 quoted by Williams, Karousou, & Markess, 2011). The Biology course is a multisection course with a common final which includes more than 80% multiple choice questions. This drives students to adopt a learning approach that discourages exploration and promotes focusing on practice questions. In addition, it discourages teachers from adopting more student-centered pedagogies. Given that this context is not likely to change, several questions arise: Is there a place for emergent learning in introductory science courses? If so, what is the optimal balance of emergent and prescriptive learning? Are there certain topics that are more suited to emergent learning and what are they? How do we "open up" assessment practices so that emergent learning is encouraged? How do we design emergent learning environments that are time-efficient for both faculty and students? Many of these questions will have to be answered before the affordances of Web 2.0 tools[1] can be realized in introductory science

[1] An annotated interactive data base of Web 2.0 tools will be maintained on the SALTISE site (http://www.saltise.ca/)

courses. One of the most important outcomes of this project may well be the discussions among science faculty of the above questions.

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Acknowledgements

The research team thanks the *Programme d'aide à la recherche sur l'enseignement et l'apprentissage* (PAREA), a MELS program, for its support. The team also thanks Dr. Elizabeth Charles for conduucting the teacher interviews and for her generous support throughout the project. We also thank our research assistants Megann Ayotte, Chao Zhang, and Marc Poissant for their dedication to the project. Lastly, we thank our colleagues and the students who participated in the study. For a copy of the complete report please see ISBN 978-1-5501699-7-3.