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Does the medium change the message? The impact of a web-based genetics course on university students' perspectives on learning and teaching

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Abstract

This study explores how university students respond to and perform in a web-based learning environment. We examine whether technology can serve as a catalyst for reforming post-secondary education, and more specifically whether it can help educators address the problem of passive learning among university level science students. To answer this question we examine students' experiences in an "autotutorial," web-based version of a third-year, university genetics course. Our findings suggest that a carefully designed technology-enhanced learning environment, which combines online and face-to-face elements has the potential to assist students in thinking differently about teaching and learning science. Thus, we conclude that the medium can change the message. © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction

During the past two decades, educators have invested extensive time and resources introducing computers and web-based courses into universities. It is evident however that the introduction of these new tools has not translated into changed pedagogical practices. Many professors use technology only as an extension of the chalkboard or overhead projector and rely upon traditional testing procedures to measure and evaluate student achievement in assessing technology's potentials. Harris (1999) notes that the prevailing pedagogical approach to technology in higher

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education is "to simply reproduce the old curriculum via the new medium of information technology (IT)" (p. 248). Unfortunately, this traditional pedagogy reinforces students' passive and rote learning strategies (Andrews, Garrison, & Magnusson, 1996; McKay & Kember, 1997). Although a constructivist student-centred learning paradigm is desirable in the university setting, post-secondary teaching methods continue to focus on teacher-directed activities (Barr & Tagg, 1995).

As critics and advocates alike clamour for a justification of computer-rich classrooms, there is a need for educators to critically investigate how instructional technologies can be used more effectively to improve teaching and enhance learning. An essential part of that investigation involves examining teachers' and students' pedagogical perspectives and roles in courses where technology is extensively used. An examination of these experiences and perspectives may lead to a deeper understanding of technology's potential role as a catalyst for initiating changed teaching and learning in the university classroom. In this paper we describe a study that begins to address these issues.

1.1. Context and objectives of the study

The context for our paper is an on-going study being conducted in a required third year university-level genetics course with an enrolment of over 500 undergraduates. Historically, this has been a traditional lecture-based course, with students attending three, 1-h large-group lectures and one, 2-h small-group tutorial session each week. Students and instructors associated with this course were concerned about students' poor understanding of basic concepts, the extreme degree of difficulty students experienced when attempting to work through the assigned problems, and the high number of failures in the course. A pilot study conducted in 1992 to better understand these learning problems led to the conclusion that many of the difficulties students were experiencing were related to passive learning tendencies. Aiming to help students overcome their passive approach to learning and improve student achievement, one of the authors (JMS) worked with the course professors and teaching assistants to design and introduce a number of alternative instructional strategies in lecture and tutorial class sessions. A collaborative study group on genetics was established, and over a series of years new teaching and learning procedures were introduced into the regular course format (Mayer-Smith, 2000). The goal of these instructional interventions was to assist students in becoming more independent and purposeful learners, and active problem solvers (Griffiths & Mayer-Smith, 2000).

After 5 years of collaboration and experimentation with different pedagogical approaches, student activity and interactivity had noticeably increased in lecture and tutorial settings. However, the majority of students enrolled in the course remained reluctant to relinquish their reliance on passive learning approaches. Based on the fact that the lecture setting was viewed as 'the culprit' that sustained traditional passive learning practices, one genetics professor (RJR) and a colleague, Dr. George Haughn, decided to try moving the course out of the lecture hall and into the virtual learning environment. An alternative "autotutorial", web-based version of the course was designed using WebCT and piloted in 1998. The modified course structure is based on a modular, self-directed, web-based instructional format (http://webct.science.ubc.ca:8900/public/biol334_201/index.html) that replaces the lecture portion of the original course (see Fig. 1 for a view of the course website). The weekly 2-h, small-group, instructor-led

tutorial session was retained as part of the course design, resulting in a hybrid instructional format that included both online and face-to-face learning opportunities. The technology-mediated version of the genetics course offers the core curriculum as 12 online modular units that students work through at their own pace. Each online module is infused with a range of learning activities, including traditional and non-traditional genetics problems, advice on learning approaches, and references to a range of web-based resources that build on and extend the textbook concepts (see Figs. 2 and 3 for samples of the module guide activities). Moving ahead to a new unit takes place when students have shown mastery by successfully solving genetics problems on tests associated with each module. In addition to the online module guide with activities, advice, and weblinks, the face-to-face tutorials, and the weekly written problem-solving tests, the course structure incorporates an electronic "bulletin board" feature providing a place for teacher or student initiated conversations, and a student help desk for individual or small group tutoring. Because students work in a self-directed manner through the course material, both students and course instructors refer to the web-based course as the "autotutorial genetics section".

Both the traditional and autotutorial versions of the genetics course have been offered since 1998. The traditional section of the course runs during the fall semester and the online version is offered in the winter term. Both sections are listed in the University catalogue under the course number, and students have the option to enrol in whichever section they prefer.

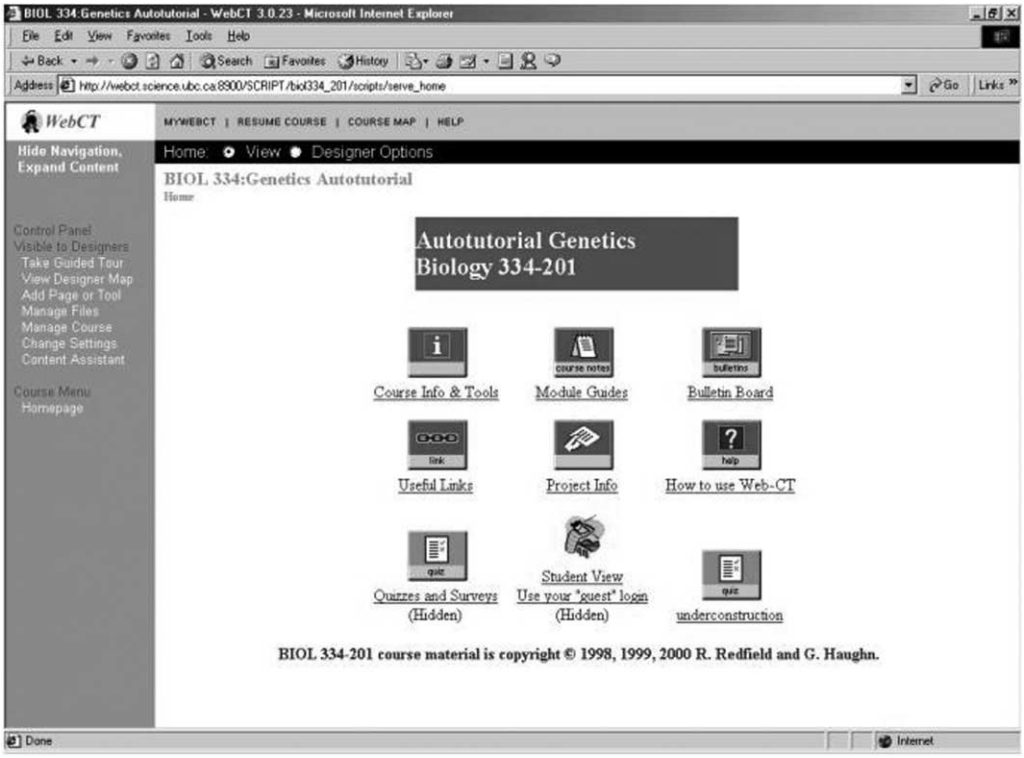

Fig. 1. Computer-based, autotutorial genetics course website shows the various online features on a WebCT format.

To explore the implications of teaching and learning university genetics in a technology-mediated environment, and the potential of this approach for improving students' pedagogical practices, a study of the autotutorial course was undertaken. The specific objectives of our study were to:

1. examine learning and teaching practices in a course that combined online and traditional instructional strategies and resources;
2. document the pedagogical roles, perspectives, and experiences of the students and instructors; and
3. evaluate the effectiveness and implications of implementing a technology enhanced learning environment as a means of changing pedagogy in higher education.

In this paper, we focus on one aspect of the larger study, namely the learners' perspectives and experiences. We ask, how do university students respond to and perform in a web-based learning environment? To answer this question we examine students' experiences with this online course. Further, we investigate whether technology can serve as an agent for reforming postsecondary education, by exploring its potential to assist students in thinking differently about teaching and learning science. Thus, we ask, does the medium change the message?

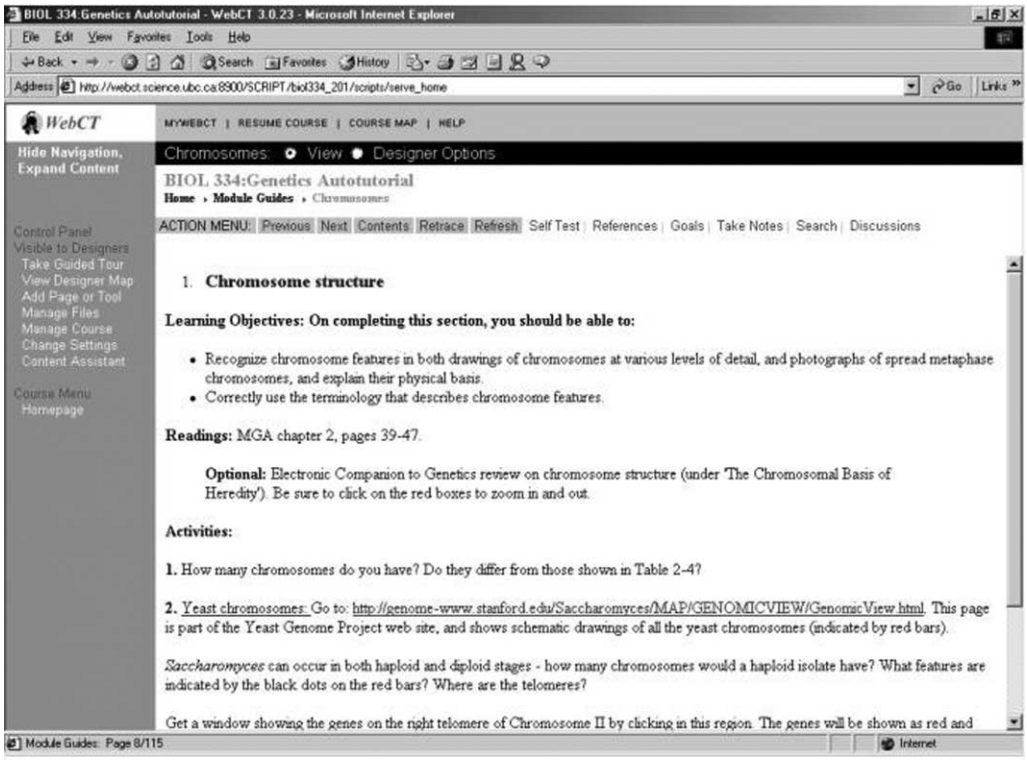

Fig. 2. Genetics online module guide sample page from Module 1 unit on chromosome structure.

1.2. Theoretical framework

Barr and Tagg (1995) note that undergraduate education has retained the traditional, professor-directed teaching paradigm when a restructuring of university settings to embrace a student-centred learning perspective is more appropriate and pertinent to our times. Arguing for a move away from the "instruction paradigm" to what they refer to as the "learning paradigm" in universities, Barr and Tagg (1995) call for a shift in pedagogical practices. Within this new paradigm, learning technologies (rather than curriculum) are developed, and quality of learning (rather than instruction) is evaluated continuously (rather than just at the end of the course). According to these educators, the goal of any undergraduate course should be to create powerful, collaborative learning environments where learning is holistic and interactive. Moreover, in this alternative paradigm, student construction of knowledge, as opposed to transfer of knowledge from faculty to student, is enacted. However, both professors and students will need to make significant conceptual shifts in their views of teaching and learning before Barr and Tagg's (1995) learning paradigm can become a reality in university classrooms.

In calling for a pedagogical shift from the conventional, teacher-directed to the constructivist, learner-centred classroom, a number of educators have advocated using new technologies as a

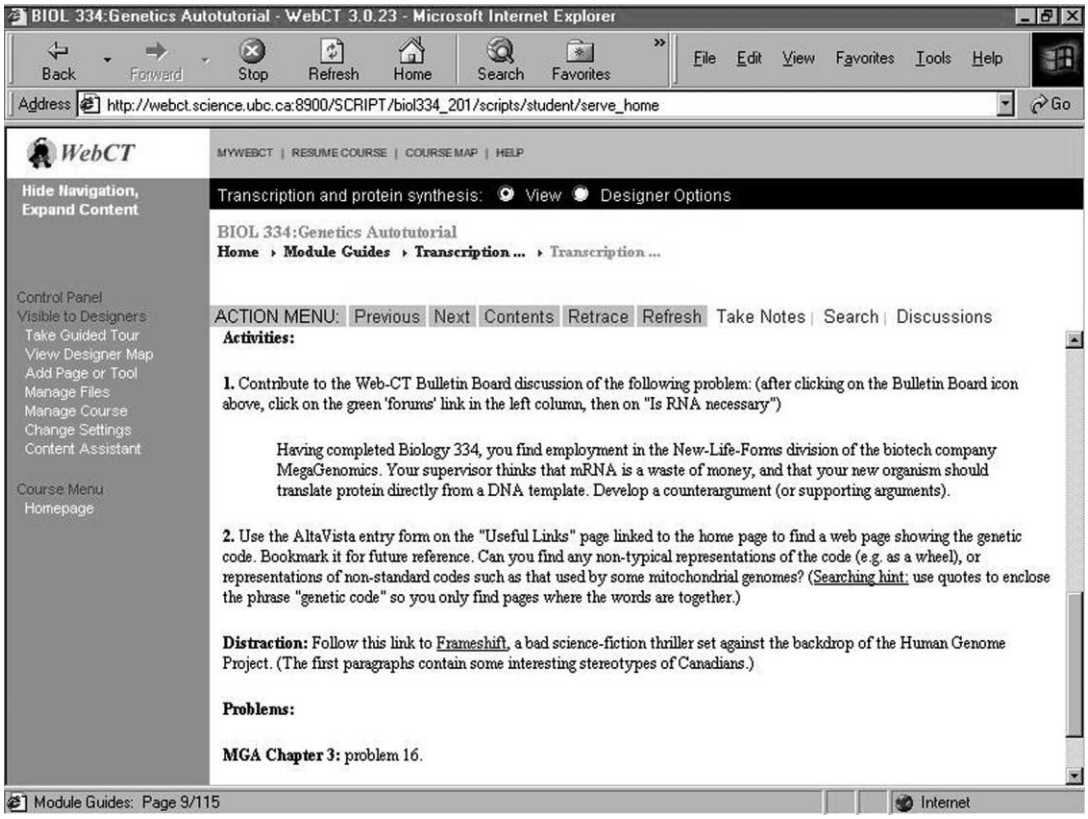

Fig. 3. Sample page of the module guide shows the variety of online learning activities students can engage with.

means of changing educational practice (e.g. Garrison, 1993; Jonassen, Davidson, Collins, Campbell, & Haag, 1995; Kent & McNergney, 1999; Laurillard, 1993; Perkins, 1992). For more than a decade, researchers have claimed that teaming thoughtful pedagogical practices with technology-rich classrooms can support a constructivist learning perspective (see Duffy & Jonassen, 1992). For example, Salomon, Perkins, and Globerson (1991) discuss how the proper use of the technology can bring about cognitive experimentation. They argue that open-ended computer activities can lead to mindful engagement and reflection on the part of the students. Laurillard (1988) points to the emancipating power of educational technologies that enables students to direct their own learning. Furthermore, Laurillard (1993) and Perkins (1992) highlight technology's capacity to scaffold (through teacher intervention) students' construction and re-construction processes.

Despite the espoused pedagogical benefits of computer-mediated instruction, many professors have used new technologies for traditional teaching (e.g. Dewhurst, Macleod, & Norris, 2000; Ward & Newlands, 1998). While using computer-based technologies to post lecture notes and text, and to set drill and practice activities is a first step in shifting pedagogy, educators remind us that technologies have more instructional potential (e.g. Laurillard, 1993; Perkins, 1992). Garrison (1993) points out that *how* technologies are used may make the difference between meaningful and superficial learning. This highlights the need for the thoughtful and "strong" design of technology enhanced courses that provide opportunities for students to actively engage with the learning materials and interact with fellow students and the course instructor. Like Ramsden (1984, 1992), Garrison (1993) argues that if we want to discourage students from passively assimilating information, course activities and assessment must provide opportunities for students to enact new and effective approaches to learning. These educators' arguments imply that when professors move away from the podium and provide activities (online or offline) that promote interactivity, collaboration, and communication among students and between student and instructor, then students will approach learning differently.

Researchers have begun to report on studies that focus on using technology to address specific student learning problems in a given context (e.g. Draper, 1998). Scaling this up to deal with learning difficulties that go beyond a particular course topic is challenging, as 'the devil is in the details' when it comes to designing technology-mediated courses. On the other hand, the problem with adopting a new pedagogical strategy for a single topic, or working on implementing learning technologies with only one aspect of a course is that these limited interventions can leave students uncritical of the problems associated with their traditional, learning approaches. We believe that moving students to approach learning differently as characterized by Garrison (1993) and Ramsden (1984, 1992) requires attention to both the details and the larger picture when designing a computer-based learning environment. The literature on learning with and through technologies that we have reviewed has not addressed the problem of helping students understand and move beyond their passive practices to adopt deep, reflective approaches to learning. Our study begins to answer this need.

In this paper, we describe how undergraduate genetics students responded to a university professor's efforts to overcome passive learning problems through adoption of an autotutorial, web-based course design. We document students' views on and experiences with computer-mediated instruction and examine technology's potential to initiate changes in postsecondary pedagogy.

2. Methods

Our ongoing study of the online course is now in its third year and employs a qualitative research approach consistent with naturalistic case study methodology (Merriam, 1998). Semi-structured interviews were conducted to provide data on students' experiences of learning and teaching in the course. In year one of the study, 33% of the students (13 of 40) volunteered to participate in interviews, and in year two, 48% of the students (24 of 50) took part in the study. During the interviews, students were asked about their beliefs about teaching, both generally, and in the course, and their experiences learning via the autotutorial, online delivery.[1]

To obtain additional data on how the course was conducted and to acquire a situated understanding of the students' experiences, two of us (JOY & JMS) assumed the role of participant observers by enrolling in the course, completing the online modular activities, attending tutorial sessions, and writing the weekly module tests.

Other sources of data for our study included (1) student bulletin board discussions, (2) informal conversations conducted with students during face-to-face tutorial meetings and module test sessions, (3) interviews with course instructors (professor and tutorial instructors), and (4) researchers' field notes. The constant comparative method (Lincoln & Guba, 1985) and triangulation (Miles & Huberman, 1994) were used to identify and confirm developing themes. While we have gained insights from the combined data sources, for the purpose of this paper we focus our presentation of results and discussion on the views and narratives gathered from the student interview data (summarized in Table 1) and bulletin board postings. These narratives are provided as evidence for our claims regarding how elements of this course appear to have influenced the pedagogical beliefs, practices and roles of the course participants.

Table 1
Students' interview responses regarding the autotutorial genetics course[a]

Responses	Percentage that agree	Percentage that disagree	Percentage that did not discuss
Preferred/liked self-paced structure of the course	64	6	30
Preferred a teacher-directed course over student-centred course	36	55	9
Preferred technology-mediated course over a lecture-based course	58	30	12
Valued working with peers in learning genetics	67	24	9
Valued online communication in the course	55	42	3
Believed the course supported independent learning	85	15	0
Believed the course promoted understanding as opposed to rote-learning	67	9	24
Believed the course promoted new learning strategies	73	9	18
Acknowledged the importance of the virtual professor in the online course	46	46	8
Believed that f2f learning needs to be included in an online course	54	0	46

[a] $n = 37$ students

[1] A copy of the interview questions can obtained from the researchers upon request

3. Results and discussion

3.1. Response of students to learning in the technology-mediated course

The majority (58%) of the undergraduate students we spoke to found the autotutorial, web-based instructional design helpful and well-suited to their particular learning approach or schoolwork ethics. These students felt that the computer-based course presented a holistic and practical orientation to the study of genetics and that it veered away from the traditional method of teaching science as terms and concepts for memorization and regurgitation during exams. This group of learners generally portrayed themselves as self-motivated, independent thinkers who preferred student-centred activities and less teacher-directed instruction. Most of these university students seemed to espouse and practice what Marton and Saljo (1984) characterized and Ramsden (1992) further explored, as a "deep approach" to learning. Jason's and Raffi's interview responses illustrate characteristics of this deep, meaning-oriented approach to learning:

> This (course) was ideal for me. I don't like lectures especially in science courses, I'm just uninterested. Lectures are unanimated (sic), are just plain boring. I don't know what a lecturer would teach you that you couldn't learn out of a textbook. I learn well reading and doing. (Jason, interview, April 30, 1999)

> (Learning for me is) understanding. I'm completely into integrating the concept into my thought patterns. That's the only way you can really use it. (In this course) since you spend all your time learning on your own instead of having someone tell you what you have to know, it's really big on understanding cause that's the only way you're going to (get it). Well, you could flash through everything and write the test the next day and pass, but you won't be learning anything. So it was very good. You're forced to understand it. (Raffi, interview, 17 April, 2000)

Alison, who had failed the lecture-based genetics course the previous term, believed the computer-based version prompted her to learn more about the subject matter than simply solving the assigned problems:

> I liked this course because I was learning about genetics rather than learning how to perform tricks. With the lecture-based course I didn't feel like I learned as much about genetics. I felt more like I was trying to learn how to perform tricks: 'Given this type of ratio, what does it mean?' And that's fine, that's interesting and it's good to be able to solve problems like that, but I also want to learn some other stuff. (Alison, interview, 4 May, 2000)

Presented with this alternative method of instruction, students reflected on their preferred learning approach and what worked or did not work for them in terms of understanding genetics concepts in this class.

> It made me realize that I don't learn anything in lectures because now I can really compare it. I do all my learning when I read, I don't do any learning when I sit and listen to someone talk at me. (Kristine, interview, 3 May, 2000)

> I'm taking the autotutorial section because I like the idea of learning on your own. Things stick if I work them out, lectures don't work for me because I tend to fall asleep or phase out after a while. (Irene's bulletin board posting, 6 January 2000)

> I liked it being web-based because I am much better visually than I am in the auditory area. So if there were things that we could look at, models or animations of stuff happening, that's really good for me." (Alison, interview, 4 May, 2000)

> I am ecstatic that someone had introduced a new way of presenting a course different from the traditional lecturing method which I find to be mostly ineffective where you forget everything the minute the exam is over. (Dennis bulletin board posting, 6 January 6, 2000)

In contrast to the first set of learners described above, the course proved to be challenging for those students (36%) who preferred a more teacher-directed, passive approach to learning. These students preferred to learn by listening to a lecture and taking down notes, as typified by Andrea's comments:

> I really didn't like the autotutorial class. I don't feel I was well prepared to deal with the style of learning that was presented. I always go to lectures because I just need to listen to someone explaining and be able to interrupt at the points where I don't understand and get answers right away. I always find that when you read, you have questions and you don't necessarily always get them answered. But if you're in a lecture, either someone else will ask the question for you or ask a question you've never thought about. I'm used to participating as I learn. The way I learn doesn't work for this class. Here you have to read the textbook and be okay with the fact that you're on your own. I don't pay (the university) to teach myself. (Andrea, interview, 17 April, 2000)

Andrea's comments illustrate that for some students the university's "instruction paradigm" has been so ingrained that they do not see their role in the learning process. These learners see their professors as the "expert" who will deliver the information that they need to learn in order to pass an exam. Based on this response to the course, it was not surprising that Andrea also reported that she found the bulletin board of little use to her, since, as she pointed out, it could not provide immediate feedback to her questions and she perceived her peers' online responses were less reliable than those of the professor.

In general it appeared that students for whom the autotutorial, web-based design did not seem to work well were those who preferred and normally adopted what Ramsden (1992) refers to as a "surface approach" to learning. These students typically focused on reproducing learning rather than working to develop an understanding of the course concepts. These students were uncomfortable with the self-directed aspects of the course and had come to depend on external motivators of learning such as teacher's feedback and assessment. Michael's and Marissa's response to the course characterize these students' views:

> I like the idea of lectures better. If you go to lectures (and) spend three hours a week with your prof for the whole term you know what your prof wants. But if you don't spend any

> time with your prof and if you don't get any feedback from your tests then how do you know what your professor wants? And unfortunately that is part of testing, knowing what your professor wants. (Michael, interview, 15 April, 2000)

> To get the marks I get I work really hard. And for this course I was working more than I usually work which is okay 'cause it's genetics, but I was frustrated by it (because of the) lack of feedback. Like one of the modules I did something like three or four times and I didn't really learn between the times I did the exam until (the professor) finally showed (the exams) to me. (Marissa, interview, 15 June, 2000)

Regardless of their preferred approach to learning, most students (85%) recognized that the web-based course was more interactive and gave them more control over their own learning than the traditional lecture-based instruction they had experienced in other courses. More than half the students we spoke to (64%) volunteered how they liked the autotutorial, modular design of the course as it provided greater flexibility for study periods and allowed them to go through the material at their own pace or leisure.

> I liked that you could go at your own pace. You can schedule it around and I really liked that aspect of it. It's on the web for me—anytime I need (it) I can go get it. (Charis, interview, 3 May, 2000)

Some students who chose to complete most of their module work at off-campus sites saw the online "distance" aspect of the course modules as an added convenience.

> I really liked the self-paced (approach), to be (working) at home. I wasn't doing it up here and I was living well over an hour away from school. (Hannah, interview, 14 May, 1999)

> I'm doing all these other things outside of school. And so it's nice for me to be able to fit it into my schedule and work when I want to and when I had time to do it. That was good for me. (Jason, interview, April 30, 1999)

These quotes and the responses of the majority of students who enrolled in the autotutorial course suggest to us that most students can take responsibility for their own learning and will accept new ways of engaging with course concepts when teaching takes place through the new medium of technology.

3.2. New messages for students emerging from the new medium

To answer our question concerning whether "the medium changes the message" we listened to and analyzed what the students participating in the autotutorial course were saying about their experiences. Data from interviews and bulletin board postings indicated students were acquiring some *new* messages about teaching and learning science.

Message 1: The web-based instructional environment supports and encourages new learning strategies and approaches.

The majority of students participating in the study recognized that the web-based instructional format encouraged an approach to learning that contrasted sharply with what took place in lecture-based courses. Students spoke about how this course design led them to reflect more and think about their understanding of the course concepts. For some students this reflection included metacognitive musings about the teaching and learning processes taking place.

> I'm not just passively listening to a lecture but actually doing it by myself. So, it puts more responsibility on me and it seems I get more out of it. I find myself having to go through the material and see what I understand and what I don't understand. (Paul, interview, 1 February, 2000)

> It's better than a lecture and you learn more. And you learn more about the way you learn, too. I started to think about strategies, paying more attention and doing more of the problems. I would set aside specific times when I would actually have to do it so that I wouldn't be doing it the night before I wanted to write a test. (Kristine, interview, 3 May, 2000)

Regardless of whether the online, modular approach matched their usual study practices, students who enrolled in the autotutorial course seemed comfortable and prepared to explore different ways of going about learning, and were willing to assume new roles and responsibilities. For some students this meant having to interact more thoughtfully with the textbook than they typically would have done in a lecture-based course. For others this meant learning to communicate regularly with the course instructor in order to clarify specific issues or concepts.

> It's the first time I've really read the entire textbook, because in other courses, you have your lecture notes to fall back on. This course, you can't just simply read through the module guide and not do anything. You have to read the textbook, understand the material and do the problems. So in that way it forces you to read everything, and I guess that's helpful." (Susan, interview, 13 April, 2000)

A number of students recognized that working through material in the online modules actually required more of their time than did their other science courses. Other researchers (e.g. Keane, Norman, & Vickers, 1991) report that this is typical for courses with online components. However, the extra time and effort required to work through the module materials were generally regarded as useful for promoting learning to a deeper understanding.

> I find that I had to do more work for this course than any other course I'm taking right now. But it's time well spent because I actually did understand." (Ana, interview, 10 April, 2000)

It appeared that through both the range of activities set for students and the alternative format, the autotutorial conveyed messages to students about how different learning strategies might lead to different levels of understanding. Students reflected on the way they approached their learning

and what they needed to change, to do well in this course. For many students, the shift was not easy but they felt that they had acquired a deeper understanding of the subject matter when they took on greater responsibility for their own learning and relied less on the instructor in the course. Students also began to recognize the important role that their peers played in their understanding of the course concepts.

Message 2: Collaboration with ones' peers can be a powerful learning tool.

Experiencing education in a course that combines online and face-to-face experiences, conveyed strong messages to students about the pedagogical significance of social interaction and public discourse. While human interaction in lecture-based courses was basically 'overlooked', opportunities for collaboration and communication with peers and instructors via the electronic bulletin board and the face-to-face tutorials were regarded as essential elements of the learning process taking place in the autotutorial course.

The opportunity to share one's ideas in a virtual space prompted the participation of some students who felt reserved about speaking out in more traditional public settings.

> (The electronic bulletin board) was one of my favorite parts of the course Yes, that was enormously successful. I liked that I got to 'talk' to people more than I would regularly in class. In a big lecture, I'm not going up to someone and say, "What do you think of module 3?" But, on the bulletin board it was just like a huge study group that you could go to whenever you wanted There's a sort of anonymity and (one) just pays attention to what they're saying and not who they are or who you think they are. (Kristine, interview, 3 May 3, 2000)

> The bulletin board gave you a sense of community. When you go to lectures you don't really talk to other students. (When using the online bulletin board) people don't know who you are so you can say whatever you want. Even if you're a shy person, you're not talking to anyone in general . (Charis, interview, 3 May, 2000)

Interestingly, some students reported that they actually had *more* interaction with peers in the 'virtual' classroom than they typically had with classmates sitting beside them in a lecture room. A number of students regarded this 'virtual' interaction as a welcome change from the isolating and impersonal environment of lectures. This perspective is evident in comments made by Vance.

> It (the bulletin board) allows you to actually get to know different students and their views on genetics. In the regular class there will be absolutely no discussion of any sort like that. It's ironic if you're in a lecture, you're physically next to people but you're not communicating with them. People sit, (pause) take notes,(pause) then leave (Vance, interview, 30 April, 1999)

Rather than feeling isolated by the autotutorial format, students enrolled in the course were comfortable and motivated to seek peer and instructor support when they felt in a learning bind.

Many of the students we interviewed volunteered that their understanding of the course material was augmented by regularly participating in bulletin board forums.

> (When I got) stuck in the module, I'd go search the bulletin board and find that someone else had asked the same question and someone else had given a good answer. (Kristine)

> every new posting is kind of informative...as well as the (student's) own views on that. So if other people read about and reply to that and have a different viewpoint, these are other considerations that you haven't thought about before and then you can learn from that. And also use that extra information to perhaps convert or modify your viewpoint a bit, to take in account more things. (Vance, interview, 30 April , 1999)

These comments suggest that the medium of online communication used in the autotutorial genetics course was conveying an important message to these university science students, namely that they could learn by listening to and valuing the ideas of their peers. These students' experiences with the electronic discussion forums bring into focus the vital role that technology can play in supporting and promoting an understanding of the social construction of knowledge.

While typically students in the lecture-based section of the course regarded tutorial meetings as an obligation rather than an asset, in the autotutorial course the face-to-face instructional setting was regarded by most of the students as time well spent. The weekly tutorial sessions that complemented the bulletin board interactions and module guide materials were generally viewed as facilitating the students' conceptual understanding.

> (What worked well for me in this course was) mostly just the solving the problem and working with other people when I could, like in tutorials or at the help desk. It's really helpful to be able to explain things to other people because then you get to straighten your brain as well. (Annie, interview, 29 April, 1999)

Not all students however, had positive experiences with the online discussions. Some students felt frustration regarding the time delay factor in communicating through the bulletin board. Others simply did not equate communicating online with human interaction. For these students, the "asynchronous" nature of the online postings was inadequate to support the type of interactive learning they felt should occur in a course.

> I didn't get my answers quick enough. I posted my questions one day and by the time they got answered I would have been done with the module." (Irene, interview, 2 May, 2000)

> I'm still new at computers and I don't like them as a form of interaction that much. I don't like to picture it (BB) as a replacement for human interaction or the classroom setting. I'd say that the tutorial sessions that we had are really good for that but not the bulletin board. It (the tutorial) provided immediate interaction whereas the bulletin board, you post something, three days later somebody might respond to it and they might have the wrong answer. You don't know who they are and you can't discuss it with them at that time (Lara, interview, 10 March, 2000)

Comments from students like Irene and Lara remind us that asynchronous communication needs to be coupled with face-to-face and synchronous interactions to address students' need for socialisation and immediate feedback in technology-enhanced courses.

Regardless of how students may view the role of online discussions, their promise for supporting student constructivist learning approaches should be further explored through research in university settings. This is highlighted by Laurillard (1993, 1995) who lists different technologies and their educational roles and calls for a re-examination of the applications of discursive media (e.g. computer tutorials and bulletin boards), as well as interactive and adaptive media (e.g. computer and tutorial simulations, respectively) in higher education. She encourages the use of these media in the design of courses, and suggests that they provide a rich venue for teacher–student interactions and feedback, which in turn can enhance students' conceptual understanding.

This highlights the fact that it is not only the roles and activities of the learner that are changing in web-based classrooms and courses, but also those of the teacher. Interestingly, however, in our study the crucial role of the course professor in the virtual learning environment went largely unnoticed by students.

Message 3: The presence of the virtual professor in a web-based course is important but her role needs to be clearly defined and communicated.

The role (and indeed the presence) of the 'teacher' in the online course was not well-defined in the minds of the students that participated in our study. Even though most of the students "liked" the course design, they had difficulty understanding the significance of the professor in the virtual classroom. It was clear that while students accepted the notion of engaging in self-directed learning in the autotutorial course they still thought of teaching in fairly conventional terms. They valued the traditional role of the professor as the course authority and felt a strong need for the presence of a human face during instruction. Similar sentiments have been expressed by students in web-based courses at other universities (e.g. McIntyre & Wolff, 1998).

> There has to be a teacher somewhere, because teachers are important. It (the web-based design) will work for some course but not for others. It is sort of the same with lectures, too (Michael, interview, 15 April, 2000)

Comments like Michael's may explain why the majority of students valued attending tutorials and perceived that this was where most of the "teaching" occurred.

To better understand the students' views of "the teacher" and "teaching" in a web-based environment, we asked them to discuss the professor's role in the online course. The array of responses suggested this question was difficult for students to answer. Some students described the professor as the "other" instructor in the course (the main instructor being their tutorial leader); others considered the professor to be "absent" and experiencing a break from the demands of teaching in the conventional sense. Still others considered the professor to be simply the course administrator and web designer. A few of the students however, recognized that the course professor played a very crucial, pedagogical 'behind-the-scenes' role in the overall design of learning activities, and the administration and implementation of the web-based genetics course. These

students understood that although the professor lacked a physical presence, she still acted as their pedagogical guide in the "virtual" classroom. They viewed her as the facilitator of the learning process as she actively participated in electronic discussions and answered queries via email or during one-on-one meetings. More importantly, this group of students recognized her voice speaking and guiding the interactive learning through the crafted module activities and selected web-based course materials.

> The modules were extremely well written. Very interesting, thought provoking. When you put it all together, it's like a textbook, all those modules and Rosie's the one that's teaching it—it's in her voice. (Holly, interview, 1 June, 1999)

> She's designing the course—making or finding the interesting problems to ask us. Making sure that the website actually leads us into the next forum rather than just being a series of notes. She explains but she doesn't put everything in there. She tries to add in elements where you have to look on your own: links and problems that make us look in the textbook, notes and elsewhere. Everything's not exactly on the website so you can't just sit there, read everything and expect to actually know everything. She made it actually interactive, made us involved in it. It's not just the links, but also the way she structured these modules and the questions she asked at specific points (Vance, interview, 30 April 1999)

The comments by Holly and Vance illustrate that moving from lectures to web-based pedagogy does not eliminate the teacher's vital role in the design of the learning environment. These quotes also lend support to the assertion that the students' sense-making in a constructivist learning environment can be effectively supported by providing ongoing teacher feedback and scaffolding in technology-mediated courses (Garrison, 1992; Laurillard, 1993). While Holly and Vance were able to clearly articulate the central role that the "university teacher" must play in the thoughtful design and implementation of computer-based courses, most students could neither imagine nor describe the role of the virtual course professor. This significant observation suggests to us that professors in technology-mediated courses need to make their pedagogical messages explicit in their course design and communicate these directly to their students.

Message 4: Computer-based instruction has some merit but should not replace face-to-face university learning environments.

All students that we interviewed were of the opinion that computer-mediated instruction had some merit, but should not replace the classroom-based experiences on campus. While reasons for this varied there was a universal opinion that some courses still needed to be taught using traditional modes of instruction. Similar sentiments have been expressed by students in web-based courses at other universities (e.g. McIntyre & Wolff, 1998). Evident in students' comments was the subtle but significant message that "University Education" is much more than the delivery of instruction and the acquisition of subject matter knowledge.

> (teaching all courses this way) would be a little depressing. University wouldn't be as exciting just because (it would change) the learning across the classroom atmosphere—you don't get

> that when you're in this autotutorial. If I go to (lecture) class everyday I establish friendships with people in that way. So, I think you would lose—the aspect of making friends in the class. But other than that, you probably do learn more in autotutorial than in a normal classroom because there is nothing distracting you—just you and the module. It's just the whole social dynamics. It's not necessarily pertaining to learning better or not, I think part of the university is also meeting people and sharing your ideas and your thoughts (Jane, interview, 17 April 2000)

But, despite some misgivings, most students believed that other university science courses could be taught "this way" and include more thoughtful, interactive learning tasks by using web-based instruction. Furthermore, participating in the autotutorial course helped students recognize that different types of subject matter warranted different pedagogical approaches by both instructors and students. The 'mixed medium' approach that was embedded in the autotutorial course design also seemed to highlight to students that there were other approaches to learning science than just listening and taking notes during lectures and participating in lab activities.

> I think it's good to have it as an option but I don't think any course should be offered **only** this way. A lot of courses that are really memory-intensive would benefit from being taught in a way that makes you do work all the way (through). Particularly in courses where you have enormous lecture sections, it would really be good to offer something that's a little smaller and lets you interact with the material. (Kristine, interview, 3 May 2000)

> Problem-based (courses) should be offered this way. But if it's really a hard material you do need someone to help you. Maybe combine ...autotutorial (with lecture-based) but I'd like to see more courses have bulletin boards because it makes you feel relieved if others are having problems with the same thing." (Charis, interview, 3 May 2000)

3.3. Computer-based instruction can serve as a catalyst for change

The autotutorial, computer-based genetics course was designed as an alternative to the lecture mode of delivery with the goal of promoting and encouraging those students who were passive, rote-learners to adopt more active, independent learning practices. Through thoughtful applications of technology in the web-based course, the focus of responsibility for learning shifted from the teacher to the student. Students who actively engaged with the course materials and interacted with fellow students and instructors in new ways were rewarded with positive experiences in the online course. After taking the course, the students reported that they believed the level of understanding they had achieved was well worth the effort.[2]

The students acknowledged however, that the process of taking on these new pedagogical strategies was not always easy. It was evident in their comments that they found it difficult to shift

[2] We would agree, for a while student achievement was not part of the story being presented here we can report that students enrolled in the autotutorial course scored as well or better on an equivalent final exam as students enrolled in the traditional course.

their practices, as they had become conditioned to listening and copying lecturer's notes. They also acknowledged that learning "this way" involved longer study periods and more self-discipline on their part. The challenges these students experienced as they grappled with assuming a more self-directed learning approach lends support to Taylor and Burgess' (1995) view that university students need to be prepared and scaffolded if we wish them to succeed in courses that take an independent or problem-based approach. In technology-based or mixed medium courses this may need to become an explicit part of the course design, or at the very least included as part of the students' online activities.

We believe that our study of the students and their experiences in this course supports the claim that the use of computer-based instruction can serve as a catalyst for changing learning approaches as well as teaching practices. This study has shown that by relinquishing the role of the "sage" who provides expert knowledge, the professor in a web-based environment can motivate students to participate in alternative learning practices and explore new ways of clarifying concepts. In the genetics autotutorial course, this motivation was accomplished through the use of a carefully constructed module guide and the inclusion of hands-on activities and weblinks that the students could explore and interact with. Commercial CD-ROM programs were provided to make learning genetics practical and less abstract. In addition, the electronic bulletin board and emails were used to promote interaction with and among the students, and to scaffold student learning, while the WebCT feature allowed for monitoring of the students' computer log-ons and course profiles. As course materials were delivered mainly through the computer instead of a lecture, concepts were presented in an interactive manner that both sustained student interest and provided opportunities for meaningful engagements with the learning materials.

Student feedback through the study also clearly showed that, though teaching takes on a different meaning in an online setting, the professor's role is crucial in the design and implementation of a technology-mediated course. She/he must relinquish some control and act as the facilitator and guide in the computer-based learning process. The professor must likewise provide scaffolding and ongoing feedback as the students interact with the course materials. As seen in the online genetics course, the medium of technology can be used in powerful ways to re-define both the student's and the professor's roles in postsecondary learning environments.

4. Concluding remarks

The IT revolution is evident in school and university classrooms in western society. This means that for those teaching in higher education, it is no longer a question of *when* and *whether* IT will enter the educational spaces of universities and colleges, but rather *how* IT should be used and how it changes the learning experience. As educators and web-designers continue to use technology in the classroom, there is a need to critically examine how they can more effectively promote meaningful learning. In our study, we explored how technology may serve as a tool to change approaches to undergraduate teaching and learning as seen through the lenses of the academy's primary stakeholders.

Findings from this study have revealed how university science students view and approach learning genetics in a computer-mediated setting. Participation in the course prompted students to reflect on their approach to learning science and illustrated the potential of learning outside of

lecture halls. Further, it illuminated the role of the teacher and the value of peer interaction in the teaching and learning process. Students' experiences with, and views of learning in this computer-mediated course, challenge educators to re-examine the existing pedagogical paradigms and roles that dominate postsecondary classrooms. The students' feedback should encourage course designers to experiment with educational technologies, and explore their potential in university settings. The narratives of the students in this study point to the value of addressing Harris' (1999) concern that faculty should move beyond simply reproducing old curriculum with the new medium of technology. Further, they illustrate that the medium of technology when used appropriately does send new messages to students about teaching and learning.

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References

Andrews, J., Garrison, D. R., & Magnusson, K. (1996). The teaching and learning transaction in higher education: a study of excellent professors and their students. *Teaching in Higher Education*, *1*(1), 81–103.

Barr, R. B., & Tagg, J. (1995). From teaching to learning: a new paradigm for undergraduate Education. *Change*, *27*, 12–25.

Dewhurst, D. G., Macleod, H. A., & Norris, T. A. M. (2000). Independent student learning aided by computers: an acceptable alternative to lectures? *Computers & Education*, *35*, 223–241.

Draper, S. W. (1998). Niche-based success in CAL. *Computers & Education*, *30*, 5–8.

Duffy, T. M., & Jonassen, D. H. *Constructivism and the technology of instruction: a conversation*. Hillsdale, N.J.: Lawrence Erlbaum Associates Publishers.

Garrison, D. R. (1993). A cognitive constructivist view of distance education: an analysis of teaching-learning assumptions. *Distance Education*, *14*(2), 199–211.

Griffiths, A. J. F., & Mayer-Smith, J. (2000). *Understanding genetics: strategies for teachers and learners in universities and high schools*. New York: Freeman Press.

Harris, M. H. (1999). Is the revolution now over, or has it just begun? A year of the Internet in Higher Education. *The Internet & Higher Education*, *1*(4), 243–251.

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. (1995). Constructivism and computer-mediated communication in distance education. *American Journal of Distance Education*, *9*(2), 7–26.

Keane, D. R., Norman, G. R., & Vickers, J. (1991). Academic computing in medicine: the inadequacy of recent research on computer-assisted instruction. *Academic Medicine*, *66*(8), 444–448.

Kent, T. W., & McNergney, R. F. (1999). *Will technology really change education?: From blackboard to web*. Thousand Oaks, CA: Corwin Press.

Laurillard, D. (1988). Computers and the emancipation of students: Giving control to the learner. In P. Ramsden (Ed.), *Improving learning: new perspectives* (pp. 215–233). London, UK: Kogan Page Ltd.

Laurillard, D. (1993). *Rethinking university teaching: a framework for the effective use of educational technology*. London: Routledge.

Laurillard, D. (1995). Multimedia and the changing experience of the learner. *British Journal of Educational Technology*, *26*, 179–189.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.

Marton, F., & Saljo, R. (1984). Approaches to learning. In F. Marton, D. Hounsell, & N. Entwistle (Eds.), *The experience of learning* (pp. 36–55). Edinburgh: Scottish Academic Press.

Mayer-Smith, J. A. (2000, April). *Interfaculty collaborative study groups: a vehicle for implementing change in undergraduate science teaching and learning*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans.

McIntyre, D. R., & Wolff, F. G. (1998). An experiment with WWW interactive learning in university education. *Computers & Education*, *31*(3), 255–264.

McKay, J., & Kember, D. (1997). Spoon feeding leads to regurgitation: a better diet can result in in more digestible learning outcomes. *Higher Education Research & Development*, *16*(1), 55–67.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.

Perkins, D. N. (1992). Technology meets constructivism: do they make a marriage?. In T. M. Duffy, & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction: a conversation* (pp. 45–55). Hillsdale, NJ: Lawrence Erlbaum Associates Publishers.

Ramsden, P. (1984). The context of learning. In F. Marton, D. Hounsell, & N. Entwistle (Eds.), *The experience of learning* (pp. 144–163). Edinburgh: Scottish Academic Press.

Ramsden, P. (1992). *Learning to teach in higher education*. London: Routledge.

Salomon, G., Perkins, D. N., & Globerson, T. (1991). Partners in cognition: extending human intelligences with intelligent technologies. *Educational Researcher*, *20*(3), 2–9.

Taylor, I., & Burgess, H. (1995). Orientation to self-directed learning: paradox or paradigm. *Studies in Higher Education*, *20*(1), 87–98.

Ward, M., & Newlands, D. (1998). Use of the Web in undergraduate teaching. *Computers & Education*, *31*, 171–184.