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Wasted on the Young? Comparing the Performance and Attitudes of Younger and Older US Adults in an Online Class on Geographic Information

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ABSTRACT *This study investigates the counter-intuitive observation that older students tend to thrive better than younger students in online classes. We use a variety of measures to compare performance and attitudes of undergraduates and continuing adult professionals in separate but nearly identical class sections led by the same instructor at a US university during the same nine-month study period. Findings are consistent with theoretical predictions about differences in readiness of younger and older adults for self-directed learning experiences. Results also suggest that online educators should be proactive in stimulating younger students' participation in class discussions, and should find ways to evaluate explicitly the tacit learning that online discussion can foster.*

KEY WORDS: GIS/S, online learning, e-learning, web-based, age, motivation

Introduction

One day during the Spring semester of 2006 an instructor at a US university received a telling pair of email messages from two students enrolled in separate sections of the same online class. One message, received from a student in a section populated by continuing adult professionals (median age 34 years), was full of excitement and gratitude: "I have learned so much more than I could have ever hoped for in a traditional classroom setting. You have made geography come alive for me again . . . Thanks for making this possible for me." The second message, received less than an hour before, came from a student enrolled in a separate class section serving undergraduate students (median age 21 years). This student apologized to instructors for neglecting his assignments: "I had [sic] fallen behind in this class of late due to forgetfulness it even existed." The two course sections were

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nearly identical with regard to educational objectives, reading assignments and other student activities, projects and evaluation methods. The same instructor taught both sections. The primary differences between the two sections were students' ages, prior experiences and their motivation for enrolling in the class.

The pair of messages crystallized a question that had puzzled the instructor for years: semester after semester, why do older students seem to thrive better in his introductory course to geographic information, science and technology, even though younger students are allegedly more accustomed to computing and information technologies? The research reported here addresses this question, as well as some of its implications—what differences in student behavior, course design and instructor roles should faculty members and administrators anticipate in relation to the ages of the students they plan to engage online? Like youth, is online learning wasted on the young?

The Distinctiveness of Adult Learning

To what extent does age help explain how individuals and groups learn? Arguments vary depending on scholars' epistemological beliefs. Those who believe that knowledge consists of representations within individuals' minds, and that knowledge acquisition involves primarily internal cognitive processes, tend to downplay the salience of age. For example, in its report *How People Learn*, the US National Research Council's Committee on Developments in the Science of Learning asserts that "the principles of learning and their implications for designing learning environments apply equally to child and adult learning" (Bransford *et al.*, 2000, p. 27). However, for those of us who are concerned about the ability of higher education institutions to provide effective *lifelong learning*, the assertion that "there is nothing distinctive about the kind of learning undertaken by adults" (Rogers, 2003, p. 7) is ultimately unconvincing (Illeris, 2006).

In contrast to the prevailing information-processing perspective, proponents of situated cognition theory conceive knowledge as "a relation between an individual and a social or physical situation, rather than as a property of an individual" (Greeno, 1989, p. 286). In this view, social interaction is critical to knowledge acquisition as learners advance from novices to experts within communities of practice by engaging problems in authentic contexts (Lave & Wenger, 1991). At the risk of overstating the difference between these points of view, one attempt to integrate them is particularly instructive in this context.

Illeris (2006, p. 16) attempted to reconcile the information-processing and situated cognition perspectives by integrating "the external interaction process between the learner and the social and material environment, and the internal psychological process." He posits his "Three Dimensions of Learning" model—cognition, emotion, environment—as a "comprehensive learning theory" (Illeris, 2003) rather than a theory of adult learning *per se*. However, as Merriam *et al.* (2007, p. 100) poined out, the application of this model to pre-adults "seems limited due to their level of cognitive and emotional development and their awareness of the societal context." Illeris acknowledged that adults differ from children in their ability to take responsibility for their lives and actions. In the same way, he argued, adult education is distinct from children's education to the extent that adults are empowered to choose what they do and do not wish to learn. Unfortunately, he noted, "The transition from child to adult has . . . become an extended, ambiguous and complicated process" (Illeris, 2006, p. 19), leading to a shared perception among both adult learners and educators that "institutionalized learning is something that belongs to childhood and youth" (p. 21).

Andragogy

Knowles (1968) imported to the US from Europe the term *andragogy* to denote a distinctive educational approach that helps adults fulfill their need for self-directed learning. According to Rossman (2000), andragogy—the art and science of teaching adults—"has gained wide acceptance as a set of assumptions designed to guide the development of programs for adults." One key assumption is the research-based generalization that "as individuals mature, their need and capacity to be self-directing . . . increases steadily from infancy to pre-adolescence, and then increases rapidly during adolescence" (Knowles *et al.*, 2005, p. 62). Knowles *et al.* claimed that, in the US at least, opportunities to take greater responsibility for learning tend to lag behind learners' increasing desire for self-directed learning (Figure 1). During the lag, *pedagogy*—the art and science of teaching children—is inappropriately applied as a result of faulty assumptions about learners' needs. In these circumstances, insufficient opportunities to exercise self-direction cause learners in the lag zone—including many US undergraduates aged 18–21 years—to be disaffected by their enforced dependency, resigned to playing passive roles in education and unprepared to play more responsible roles when such opportunities do arise.

The andragogical model illustrated in Figure 1 predicts differences in performance and attitudes between post-adolescent and older adult students. Such differences are evident in a number of research studies. For example, Richardson (1997) presented evidence that 'mature' students (those aged 22 or over in undergraduate programs or 25 or over in postgraduate programs) strive for deeper levels of learning, are intrinsically motivated, manage time better and perform better than traditional-age students (undergraduates under 22 years or postgraduates under 25 years), who, by contrast, tend to be satisfied with superficial understanding and may lack intrinsic motivation. In fact, Richardson (1994) contended that the quality of academic programs can be improved by increasing the intake of mature-age students. Similarly, Hartley and Trueman (1997) noted a lack of intrinsic motivation in traditional-age students when compared with mature-age students.

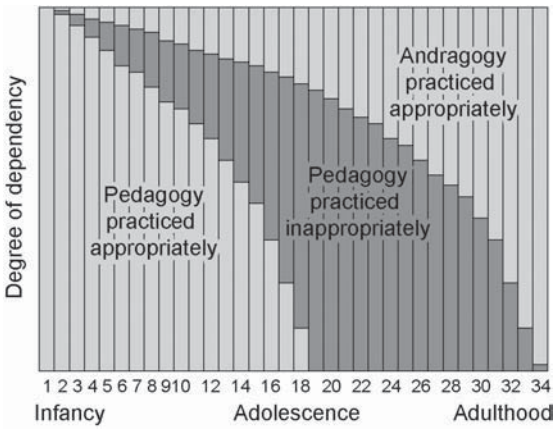

Figure 1. The lag (labeled 'pedagogy practiced inappropriately') between individuals' increasing need to direct their learning experiences as they mature, and the extent to which formal education accommodates that need. After Knowles *et al.* (2005).

Newstead *et al.* (1997) found that mature-age students performed better on exams and cheated less than younger adult students.

Younger and Older Adults Online

The andragogical model also predicts that younger adult students in online courses and programs are likely to be particularly disadvantaged, since "technology demands that learners be ready for self-directed learning" (Knowles *et al.*, 2005, p. 237). Several studies support this prediction. For example, Velasek (2001, p. 11) concluded that college students aged 30 and older "are more likely to persist and succeed in online classes than traditional college-age students (aged 18–24)". Moore *et al.* (2002) presented evidence that younger, less experienced students are most likely to withdraw or fare poorly in online classes. Hartmann *et al.* (2005) reported results of a survey of nearly 1500 online learners that sheds light on differences in attitudes and expectations among students born during 1946–1964 (the cohort authors nicknamed 'Baby Boomers'), students born during 1965–1980 ('Generation X') and others born during 1981–1994 (the so-called 'NetGen' students). Among these were older students' greater tendencies to be engaged with their studies, to value interactions with peers and instructors, and to modify their learning strategies to take best advantage of the online format.

Time management is a crucial learning skill for online learners. Hiltz (1994) identified inadequate student time-on-task as a prime cause of lower retention rates in online classes relative to classroom classes. Velasek (2001) noted several studies that demonstrate the critical importance of time management for success in distance learning in general and online learning in particular. Furthermore, Lundberg (2003) reported that older students (30 years of age and older) were able to manage time limitations more effectively than younger students.

The salience of age in explaining differences in student performance in the classroom and online is evident in a meta-analysis of 96 research reports by Sitzmann *et al.* (2006). Their analysis of the performance of 19 331 'trainees' in 168 different courses including psychology, engineering, computer programming, business and technical writing revealed that Web-based instruction (WBI) was 6 per cent more effective than classroom instruction (CI) for teaching *declarative* knowledge. However, "the extent to which Web-based trainees learned more than classroom trainees increased as the age of the Web-based trainees increased and the age of the classroom trainees decreased" (p. 642). In aggregate, mean student age accounted for 44 per cent of the total variance in student performance. On the basis of these findings, Sitzmann *et al.* (2006, p. 653) concluded that research is "needed to assess why trainees aged 23–45 tended to learn more declarative knowledge from WBI than CI but trainees aged 18–22 tended to learn more declarative knowledge from CI than WBI".

Evidence reported above could lead one to conclude that online learning is inappropriate for younger students. Indeed, Paloff and Pratt (2001) have noted that "in general, distance education has been applied to and seen as most successful in the arena of adult and continuing education" (p. 109). However, a Sloan Foundation survey of over 2000 higher education institutions revealed that 82 per cent of the nearly 3.2 million US students who enrolled in online courses in Fall 2005 were undergraduate students (Allen & Seaman, 2006). Although the Sloan survey results did not include age or other demographic data, according to the US Census Bureau (2005), the median age of

undergraduate students enrolled full- or part-time in October 2005 was 20–21 years, and about 73 per cent of undergraduates were 24 or younger. It is worth noting that the Sloan survey reported an annual growth rate of 18 per cent in online enrollments.

The situation at our institution is typical of this trend—Penn State has made it a strategic priority to increase its capacity to offer online courses and programs to national markets of off-campus adult learners as well as to on-campus undergraduate and graduate students. For this reason, units like ours that plan and implement online courses and programs must prepare faculty members to be effective facilitators of both younger and older learners. At the same time, if evidence indicates that some student cohorts are not well served by online learning, it is our duty to advise administration accordingly, and to propose alternatives that accommodate both student needs and institutional goals. In this regard, one promising alternative is 'blended' or 'hybrid' classes and programs that can be designed to exploit affordances of both online and face-to-face formats. Discussion of this alternative is beyond the scope of this paper, but is considered elsewhere (e.g. Picciano & Dzubian, 2007).

Generational Differences

The studies cited above support the counter-intuitive notion that older students (those whom Prensky (2001) nicknamed "digital immigrants") are more likely to succeed in online classes than the so-called "digital natives". These findings are somewhat puzzling if one assumes that younger students are, as a group, more comfortable with information and communication technologies than their older counterparts. Since the digital natives grew up with information technology, should not they be more likely to succeed as online learners than the digital immigrants?

Lim (2001) showed that "computer self-efficacy"—the perception of one's capability to use computer and information technology—can be an effective predictor of student satisfaction in an online course. Miller *et al.* (2003) demonstrated that perceived ease of use and usefulness were strongly, positively correlated with the amount of time and effort students devoted to an online course. Similarly, Sitzmann *et al.* (2006, p. 653) concluded that "trainees' previous experience with computers and the Internet may be one of the best predictors of learning from the Web". However, results of their survey of 280 students led Garcia and Qin (2007) to conclude that "even if younger students have greater levels of comfort or proficiency with new technologies, it is still debatable whether such traits necessarily entail more open, progressive or positive perspectives of the educational process." In particular, Garcia and Qin noted a prevalent perception with younger students—that online courses require less time than face-to-face courses.

Scholars such as Vaidhyanathan (2008) urge caution in characterizing an entire generation of individuals as "digital natives" or "digital immigrants" because this "ignores the vast range of skills, knowledge and experience of many segments of society." Generalizations of this sort, he and others have argued, tend to privilege some individuals while marginalizing others, since they "focus on people of wealth and means, because they get to express their preferences (for music, clothes, technology, etc.) in ways that are easy to count." Even Prensky (2009) admitted that the distinction between "natives" and "immigrants" is becoming less relevant. Still, it remains true that higher education institutions confer degrees upon students whose ages tend to be tightly clustered (for example, see US Census statistics cited above). It is also true that many faculty members

are a generation older than the students they teach. For these reasons, those of us who are responsible for designing, implementing and sustaining academic programs—including those offered wholly or partly online—must do so mindful of the general characteristics as well as the diversity of the students we aim to serve.

The andragogical model leads us to expect that students in the older cohort of the class considered in this research, whose median age is 34 years, were better prepared to have satisfactory experiences in an online course than were students in the undergraduate cohort (median age 21 years). The quasi-experimental study reported here was designed to help estimate and explain differences in the performance and attitudes of younger and older adult learners. This research provides a richer portrayal of student performance and attitudes than is typically provided in earlier research, much of which relies solely on test scores or survey methods. We do so by employing a mixed-methods research design that includes quantitative and qualitative analyses of student activity data harvested from a Web-based learning management system, surveys and interviews, and scores on quizzes, exams and assignments. Our research objectives were to inform educators' and administrators' expectations about the different age groups they serve, as well as to improve our own professional practice by understanding our students, and ourselves, better.

Course Description and Student Characteristics

The context of this research study is a course that provides an introduction to the properties of geographic information and the technologies and professions by which it is produced and used. The lead author developed the initial version of the course in 1997 as a face-to-face class for first- and second-year undergraduate students (DiBiase, 1996). "GEOG 121: Mapping Our Changing World" was compulsory for students seeking the Bachelor of Science degree in Geography, but it was also available to any student enrolled at Penn State University as an elective that satisfied three out of the six required credits in social science general education. GEOG 121 has been offered in the Fall and Spring semesters since academic year 1997–1998. By academic year 2006–2007, annual enrollments increased from 185 to 403. Interestingly, the number of Geography majors enrolled in the class remained relatively constant over this period, averaging 45 students per year. Meanwhile, the number of students seeking degrees other than Geography who enrolled to fulfill the general education requirement increased markedly, from 109 in 1997–1998 to 355 in 2006–2007 (DiBiase, 2007). An especially large enrollment increase occurred between 2005–2006 and 2006–2007, when the Department of Geography added an online section of GEOG 121.

About the same time that the original classroom version of GEOG 121 appeared in 1997, Penn State embarked on a new distance education venture known as the "World Campus". In 1998, the World Campus invited the Department of Geography to develop a four-class certificate program in GIS to be delivered online to current and aspiring GIS professionals. The lead author accepted responsibility to lead the curriculum planning and course development effort, in collaboration with instructional design and marketing staff at the World Campus. Since it could not be assumed that students would have a formal background in the field, he envisioned the first class in the four-class sequence as an online version of GEOG 121, the introductory GIS course described above. Beginning in 1999, "GEOG 5121: Nature of Geographic Information" was offered initially as a non-credit course. In 2004, the class was approved as a for-credit offering and was renumbered as GEOG 482. From 1999 to 2006, the class attracted over 2000 enrollments in 32 quarterly

course offerings. GEOG 482 and 121 differ in their intended audiences, and in their duration—like other courses in the World Campus certificate program, GEOG 482 is offered in a compressed, 10-week term schedule rather than the 15-week semester schedule to which undergraduate classes conform. In most other respects, however, GEOG 482 and the online version of GEOG 121 were identical during the Fall 2005–Spring 2006 period during which data for the current study were collected.

Figure 2 illustrates the key components of GEOG 482 and the online version of GEOG 121 during the study period. Both classes were conducted in ANGEL, a proprietary learning management system. Neither class included face-to-face meetings of instructors and/or students. Students in both classes encountered the same lessons and project assignments. Nine lessons were presented as a series of nearly 200 HTML pages that displayed text, graphics, animations, visits to topical websites and challenges to identify comparable local examples.[1] Punctuating the nine lessons was over 40 automated 'open-book' quizzes that enabled students to self-assess their mastery of lesson objectives. In addition to lessons, students were assigned three projects. These assignments required students to prepare original reports using Web-based resources (for example, the US

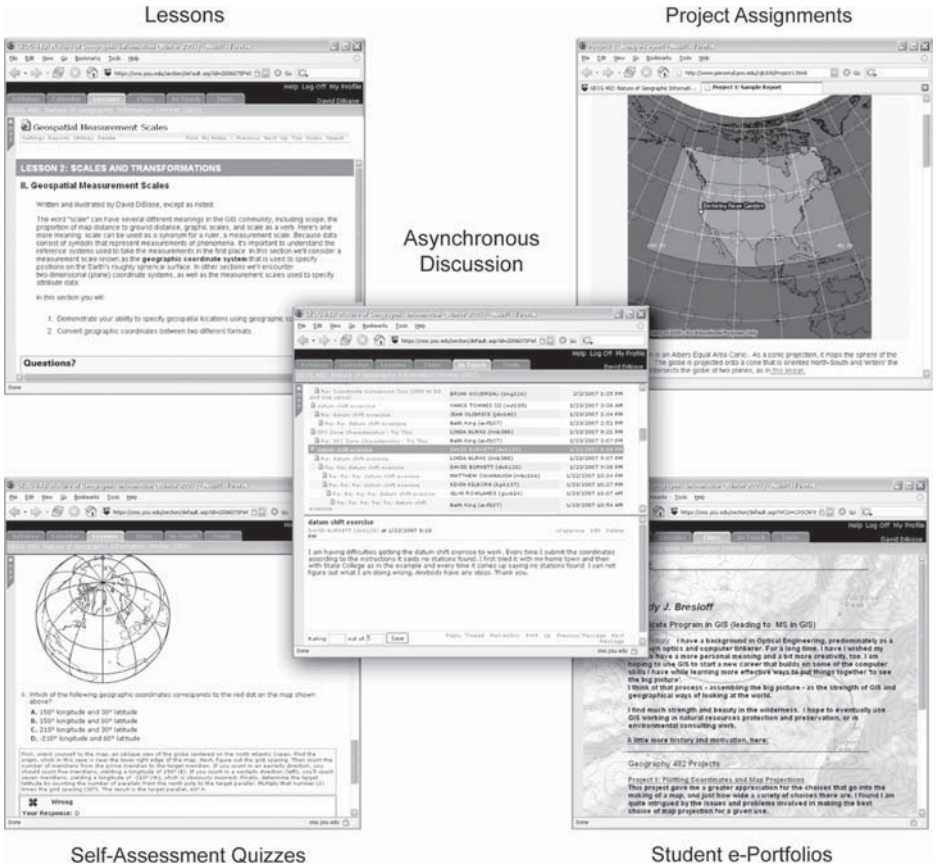

Figure 2. Components of the online course, as represented in the ANGEL e-learning management system and in students' e-portfolios.

Census Bureau's American FactFinder site), and to publish their reports online as part of a personal e-portfolio. Every student received a detailed, individual critique of his or her project report from the course instructor or an assistant instructor within one week of the project due date. Although they were never required to log in to class at a particular time, students were expected to keep pace with a weekly schedule of quizzes and project assignments. Students were allowed to ask for help directly from instructors by email; they were also encouraged to share questions and comments asynchronously in message boards that were open to every student. Instructors typically replied to student inquiries within 24 h, though some questions and comments in message boards were left a little longer to tempt student replies and conversation.

Table 1 compares the demographic characteristics of the 178 continuing adult professionals who completed GEOG 482 in the Fall 2005 (October–December) and Winter 2006 (January–March) terms with the 101 undergraduates who completed GEOG 121 during the Fall 2005 (September–December) and Spring 2006 (January–April) semesters. The key differences among these cohorts are their age (median age of students enrolled in GEOG 482 was 13 years higher) and their reasons for enrolling (many undergraduate students enrolled in GEOG 121 to fulfill a general education requirement, whereas practically all GEOG 482 students enrolled in hopes of launching or advancing careers in the GIS field). Other differences include age range (43 years for GEOG 482 students versus only 11 years for GEOG 121 students) and the fact that while all GEOG 121 students resided at the University's main campus, GEOG 482 students were dispersed across the US and, in a few cases, overseas.

Data and Methods

Data sources included records of the student activity within the ANGEL learning management system; student emails and discussion board postings; activity diaries kept by the lead author who also served as the instructor of GEOG 482 and 121 during the study period; surveys of student attitudes conducted within ANGEL and semi-structured telephone interviews with select undergraduate students. First, we discuss the data and associated analytical methods, and then present the results of our analysis in a later section.

Student Activity Logs in ANGEL

Time-on-task is a necessary, if insufficient, condition for student learning (Bransford *et al.*, 2000). We used student time spent logged into the GEOG 121 or 482 class

Table 1. Comparison of student characteristics in two separate sections of the online course

	Continuing adult professionals GEOG 482 Fa05 + Wi06, $n = 178$	Undergraduates GEOG 121 Fa05 + Sp06, $n = 101$
Age (median)	34	21
Age (range)	22–65	19–30
Female	26%	22%
Male	74%	78%
Most common reason for enrolling	Career advancement or career change	Major requirement or major elective or general education

sections within the ANGEL learning management system as an approximate measure of student time-on-task and as a surrogate measure for learning. ANGEL facilitates this analysis by routinely recording timestamps when students log into and log out of the system as well as the activities (and times) in which they engage while logged in. Figure 3 shows portions of two individual activity logs associated with the two students whose email messages to the instructor are quoted at the outset of this article. In this representation (a standard ANGEL function provided to instructors), dark rectangles represent the days and times during which each student was logged into the ANGEL system over a 21-day period.

Activity log data was extracted from ANGEL in the form of a text file. Each line in this file contained a record of the user ID of the individual that initiated the activity, the timestamp when the activity took place and the type of activity (for example, logging in, taking a quiz, submitting an assignment, visiting a link, opening a folder, logging out, etc.). The size of these activity logs was proportional to the amount of activity that took place in a given course during a given semester. The activity files associated with the four semesters that comprise the study period ranged from less than 40 000 records (GEOG 121, Fall 2005) to nearly 140 000 (GEOG 482, Winter, 2005). The difference in raw student activity between the two classes was striking given that GEOG 482 was offered during a 10-week term as compared to GEOG 121 which was offered during a 15-week semester; the Winter 2005 offering of GEOG 482 had 97 students while the Fall 2005 offering of GEOG 121 had 44 students.

Our analysis of this activity data went beyond comparison of raw total activity within a class. The second author developed PERL scripts[2] to read the activity logs and calculate the duration of each individual session (where 'activity' is a period of time bounded by a 'login' and 'logout') for every student. To exclude what was likely to be spurious data, the PERL script was set up to ignore individual sessions in ANGEL that were greater than one hour in duration. It was assumed that in such cases students were likely to have turned their attention away from ANGEL to other activities without logging out. The remaining times were considered to be a reasonable approximation of student time-on-task. It is worth

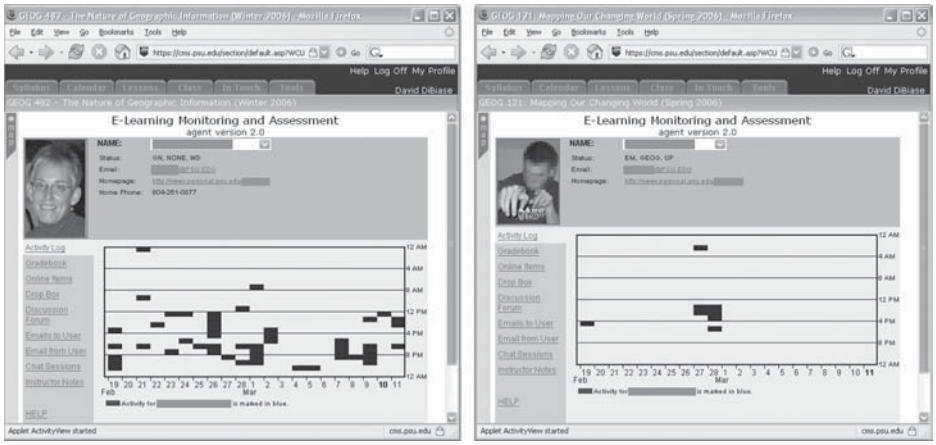

Figure 3. Portions of ANGEL activity logs of two students enrolled in GEOG 482 (left) and GEOG 121 (right). The student on the left approved use of her ANGEL profile picture in this publication. The student on the right asked that his identity remain private.

noting that the two groups reported similar preferences for studying online versus printing lessons and reading offline in formative assessments administered during the courses.

Student Message Board Postings and Email Messages

In ANGEL, 'message boards' are forums for asynchronous threaded discussion among students and instructors. In both GEOG 121 and 482, message boards were available for each lesson and project assignment. Students were encouraged but not required to post messages in the message boards. Students' voluntary participation in class discussions was considered to be a second indicator of engagement and another surrogate measure for learning. The total number of message board postings and the number of postings per student in GEOG 121 and 482 were calculated. In addition to this quantitative comparison, a content analysis of over 1600 message board postings was performed to compare the quality of conversations within the two cohorts.

To facilitate content analysis, the second author first assigned two attributes, each with two levels, to every message: 'posting' or 'reply' and 'posted by a student' or 'posted by an instructor'. To develop a third attribute, the two authors independently identified common themes in the messages. After a few iterations, the authors reached consensus on two primary categories—*procedural* and *substantive* messages. Procedural messages were those concerned with practical matters such as course policies and interface. Substantive messages, on the other hand, related to the knowledge and skills that the courses aimed to help students master, including, but not limited to, the subject domain of geographic information science and technology. Within the procedural and substantive categories, seven sub-categories were identified. Each of these sub-categories is outlined in Table 2 along with representative examples. Postings that did not fit any of these categories were tagged as 'unclassified'. Such postings totaled less than 10 per cent of all posts. Postings in a message board devoted to personal introductions during the first week of class were not coded.

In this way, each of the over 1600 messages were assigned three attributes: 'post' or 'reply', 'student' or 'instructor' and one of the seven subcategories listed above. A qualitative data analysis software product called NVivo was used to facilitate the tagging process. Once the tagging process was complete, *queries* were created that counted the number of postings for different combinations of attributes, for example, one query counted the number of *posts* by *students* that pertained to *GIS Concepts*.

Finally, counts of student messages within the two GEOG 121 offerings and the two GEOG 482 offerings were added for each combination of attributes, yielding counts for younger students (GEOG 121 Fall 2005 + Spring 2006) and older students (GEOG 482 Fall 2005 + Winter 2006). These counts were divided by the total number of students enrolled in GEOG 121 (101) and 482 (178), respectively, yielding an average number of messages per student in each sub-category for each course. For instructor messages, counts were divided by the number of students enrolled to yield per-student averages. See the Results section for the outcomes of these analyses.

Student Performance on Assignments

Instructors evaluated student learning in GEOG 121 and 482 by nearly identical means. Students were asked to demonstrate mastery of educational objectives in three project

Table 2. Categories and sub-categories used in the qualitative analysis of student and instructor message board postings

Sub-categories	Definitions	Example messages
Procedural messages		
Administrative	Questions and comments about the course calendar (e.g. due dates for assignments, scheduling conflicts), grading and other policies (e.g. rubrics for grading, late submission, format of exam), prerequisites for the class, suggestions for improving the quality of the course, and other general comments and questions	"When the due date says 1/31 does that mean its due by Tuesday@12 am, Wednesday@12 am, etc?"
		"When will project 1 revised grades be complete for those of us who resubmitted?"
Technical (including ANGEL use)	Questions and comments about the learning management system (e.g. access to 'locked' resources, resetting password) and other technical issues (e.g. questions related to platforms—different operating systems, browsers; problems playing Flash animations)	"I did the gateway quiz, but project one is still locked. They are asking for an access code. I assumed once I took the quiz that the project would be accessible to me? Did anyone else have this problem . . . ?"
Substantive messages		
Citation Rules	One of the learning objectives of the course is to be able to use the APA citation format and to develop awareness of issues related to copyright. Messages in this category were related to APA citation rules and use of copyright material	"I was just wondering how to cite our online text book, can we just cite it as a regular book? or is there a special notation style we have to use because it is online? Thanks!"
GIS Concepts	Questions and comments about concepts discussed in the lessons and assignments	"Hi All, I'm having some trouble conceptualizing standard lines and the UTM projection. If the standard line of a cylindrical projection is defined as the meridian at which the cylinder is tangent to the globe, how is it that the UTM projection employs two standard lines? i.e. How can the cylinder be tangent to a sphere at two points?"
GIS Software	Examples of GIS software and GIS data sources that have applications in day-to-day life; comments and personal opinions (pros and cons) about GIS software, and technical questions (e.g. file formats, installation issues, how-do-I and how-to, etc.)	"How do I get my thematic map [created at factfinder.census.gov] to show data at the census block level? Everything I've tried gives me county averages. I know we're not THAT homogeneous!"

Table 2. *Continued*

Sub-categories	Definitions	Example messages
GIS Trivia	Amusing matters of small importance discovered on the Internet, television shows, radio, newspaper, journal articles, as well as personal anecdotes	"It is now 12:15 CST. The History International channel is showing the history of maps if anyone is interested"
Web Publishing	One of the learning objectives of the course is to be able to publish a class project on the Web. Messages in this category were questions and comments regarding the process and design of Web pages as well as Web publishing software	"When I uploaded my project to my webpage my picture wont show up. It worked though all the way before that. What can I do to fix it?"

reports (which together account for 50 per cent of the final grade), eight graded quizzes (25 per cent of the final grade) and a final exam (25 per cent of the final grade). Projects required students to (1) demonstrate fluency with geographic coordinate systems, data and map projections; (2) create and interpret thematic maps depicting census data and (3) investigate a topic of their choice related to geographic data production. Students 'published' project reports in personal e-portfolios. Report templates were provided for the first two projects; by the third project, students were expected to be able to produce illustrated HTML pages independently. Instructors used Turnitin.com[3] to assure the originality of students' project reports. For consistency they also used standard rubrics to evaluate the reports. Rubrics were disclosed to students as part of the project assignments.

Nine class lessons included 42 automated, multiple-choice quizzes implemented within the ANGEL learning management system. Students were encouraged to consult lesson texts while responding to the quizzes. Most quizzes were low-stakes 'practice' quizzes meant to make the lesson objectives explicit and to help students self-assess their mastery of the lesson objectives. Lessons 2–9 also included graded quizzes intended to encourage students to study lessons carefully. Both practice and graded quizzes provided individual scores and comments immediately after students submitted their responses. Like the quizzes, the format of the final exam was multiple-choice. Unlike their older counterparts in GEOG 482, GEOG 121 students were required to appear in person for a proctored final exam during which they were not permitted to consult the lessons. This was intended to encourage GEOG 121 students—most of whom resided nearby the University's main campus—to study lessons independently. GEOG 482 students (all but a few of whom were dispersed across North America) were allowed to consult the lessons during the exam. Mean scores earned by GEOG 121 and 482 students were compared for each of these assignments.

Instructor Activity Diary

The lead author led both GEOG 121 and 482 as the instructor throughout the study period. From August 30, 2005 to May 30, 2006, he maintained a daily diary of time spent attending to the courses. In these diaries, he recorded all class-related activities greater than five minutes in duration. Activities included communicating with students via ANGEL message boards or course email; developing educational resources, including

revising the online text, assignments and quizzes; setting up the course prior to each new term (i.e. creating new instances of the course within ANGEL with updated assignment schedules); and evaluating assignments. Graduate student assistants graded most student assignments in both courses, but since they did not maintain activity diaries consistently throughout the study period, their data were not considered in this analysis.

Student Surveys

At the conclusion of each class, term students were asked to respond to a set of surveys that were delivered in ANGEL. The end-of-term surveys included questions from Penn State's "Student Ratings of Teaching Effectiveness" (SRTE) survey which consists of four or more seven-step Likert-type scales that students use to rank the quality and effectiveness of class and the instructor. Responses to the SRTE are collected anonymously. While not indicative of the effectiveness of a course in achieving its learning objectives, the SRTE has been shown to be a reliable measure of student satisfaction (Dorris, 1997). Response rates were 77 and 75 per cent, respectively, for GEOG 121 and 482. Student responses to the first two questions in the SRTE are considered in this study: (1) "rate the overall quality of this course" and (2) "rate the overall quality of the instructor". To compare satisfaction of the younger and older students, we used the non-parametric Kolmogorov–Sminov (K–S) statistic to evaluate the similarity of the distributions of student ratings within each cohort. The K–S test is a non-parametric statistic that evaluates the differences between two ordinal-level data distributions. An alternative to the Mann–Whitney *U*-test that is recommended for datasets that include a high frequency of tied values, the K–S statistic tests the null hypothesis that two samples are drawn from identical populations by comparing cumulative frequency distributions of the samples. A difference in frequencies associated with any category in the two distributions that is greater than what would be expected by chance under the null hypothesis suggests that the samples are in fact not identical (Blalock, 1979).

In addition to the end-of-term SRTE surveys, an additional survey of students enrolled in the Spring 2006 offering of GEOG 121 and the Winter 2006 offering of GEOG 482 was conducted. This survey consisted of 50 items intended to reveal students' learning styles and preferences, computer skills and previous experience and demographics. Most items permitted students to select a ranking on a five-step Likert-type scale to indicate their agreement or disagreement with a given statement, such as "I have the discipline needed to complete assignments independently." Some items allowed students to elaborate on their answers with open-ended textual responses. Survey response rates were 79 per cent for GEOG 121 (45 of 57 students) and 90 per cent for GEOG 482 (73 of 81 students). A key item for this study is the respondents' agreement or disagreement with the statement "I am highly motivated to do well in this course." Whereas only two-thirds of GEOG 121 students agreed or strongly agreed with that statement, 90 per cent of GEOG 482 students described themselves as highly motivated. Attitudes of the subset of 'highly motivated' younger students are compared with those of the entire younger and older cohorts at the end of the Results section.

Student Interviews

As discussed below, differences in attitudes are apparent between the younger and older students even after self-reported motivation is taken into account. To understand these

differences better, we interviewed by telephone five undergraduate students who self-identified as 'highly motivated'. Telephone interviews were conducted in Summer 2006, after the courses had concluded and semester grades were received. Comments from some of these interviews are discussed below. The interviewer (a learning design specialist assigned to assist the instructor in designing and developing the online course) asked each interviewee 14 open-ended questions concerned with students' reasons for enrolling, level of interest, study habits, prior experience and expectations. Interviews were recorded with students' permission; both authors analyzed the transcripts of these interviews.

Results

Older Students Invested More Time

The older and younger cohorts differed markedly in how often they logged into the ANGEL course section and how long they remained logged in. As shown in Table 3, GEOG 121 students as a group logged in one-third less frequently, and stayed logged in only one half as long as their older counterparts in GEOG 482. These findings are particularly remarkable in light of the fact that GEOG 121 lasted 15 weeks instead of 10.

As explained above, we consider the login frequency and duration to be approximate measures of student time-on-task, and time-on-task to be a necessary but insufficient condition for learning. ANGEL activity logs indicate that the 178 GEOG 482 students logged in 21 909 times during the Fall 2005 and Winter 2006 terms, while the 101 GEOG 121 students logged in only 8123 times during the Fall 2005 and Spring 2006 semesters. Average logins per student are shown in Table 3. In addition, our analysis of activity log data reveals that the older GEOG 482 students remained logged in for a total of 9973 hours during their two 10-week terms, while the younger GEOG 121 students remained logged in for only 2872 hours during their two 15-week semesters. To confirm this analysis, we compared the log data to students' own estimates of the number of hours per week they devoted to the class. In response to a question included in a survey administered in February 2006, the median response of GEOG 482 students was '9–12 hours' as compared to '4–8 hours' for the GEOG 121 students. A K–S test comparing these estimates indicated a significant difference between the two cohorts. Taken together, these results lead us to hypothesize that, by virtue of their greater investments of time, older students in GEOG 482 benefited more from the experience than the younger students in GEOG 121. As we will see, however, the evidence we collected is inadequate to test that hypothesis.

Table 3. Frequency and duration of student time-on-task in separate sections of the online course

	Continuing adult professionals GEOG 482 Fa05 + Wi06, 10-week courses	Undergraduates GEOG 121 Fa05 + Sp06, 15-week courses
Logins per student per term	123	80
Hours logged in per student per term	56	28

Older Students Participated More in Voluntary Communications

Swan *et al.* (2000) identified active participation in online discussion as one of the three crucial factors in the success of online learning. Students in both GEOG 482 and 121 were encouraged but not required to post questions and comments in the message boards associated with each lesson and project assignment, or to contact the instructor privately by course email within ANGEL. As explained above, we analyzed the quantity and characteristics of student communications as measures of the quality of their educational experiences. Data presented in Table 4 show that, as a group, the younger undergraduate students in GEOG 121 participated in class communications—public message board postings and private email messages sent through the ANGEL system—at less than half the rate of their older counterparts in GEOG 482.

In the previous section, we explained how student message board postings were classified as 'procedural' or 'substantive'. Our qualitative analysis of message board postings revealed that approximately 71 per cent of the messages that undergraduates posted were substantive (117 out of the 165 messages), in comparison to 82 per cent for GEOG 482 students (944 substantive messages out of the 1146 messages). Figure 4 shows the distribution of message board posts for GEOG 482 and 121 students among the two procedural and five substantive sub-categories. We believe that adult professionals' greater familiarity with and interest in the subject domain of geographic information science and technology explains their much greater propensity to contribute messages overall, and their somewhat greater tendency to post messages that were substantive in nature.

Comparable Scores on Project Assignments, But . . .

Table 5 compares the mean performance of the two student cohorts on class assignments. As described in the previous section, students in both cohorts were required to complete three project reports, eight graded online quizzes and one final examination. Project assignments and quizzes were identical for the two cohorts. In Table 5, 'project scores mean cumulative' are average points earned as a percentage of the total points available for all three projects. 'Project 3 scores mean' isolates the average scores earned on the third project assignment, which we highlight because it accounted for the largest portion of students' class grades. Average scores suggest that younger students in GEOG 121 performed equally well as their older counterparts despite having devoted considerably less time logged into the course lessons. However, a greater incidence of academic integrity infractions was detected in project reports submitted by the undergraduates (9.9 per cent) in comparison with the continuing adult professionals in GEOG 482 (3.9 per

Table 4. Frequency of voluntary student communications in separate sections of the online course

	Continuing adult professionals GEOG 482 Fa05 + Wi06	Undergraduates GEOG 121 Fa05 + Sp06
Message board postings per student	4.2	1.9
Message board replies per student	4.1	0.6
Total	8.3	2.5
Mail messages initiated per student	2.0	0.9
Mail message replies per student	2.0	0.7

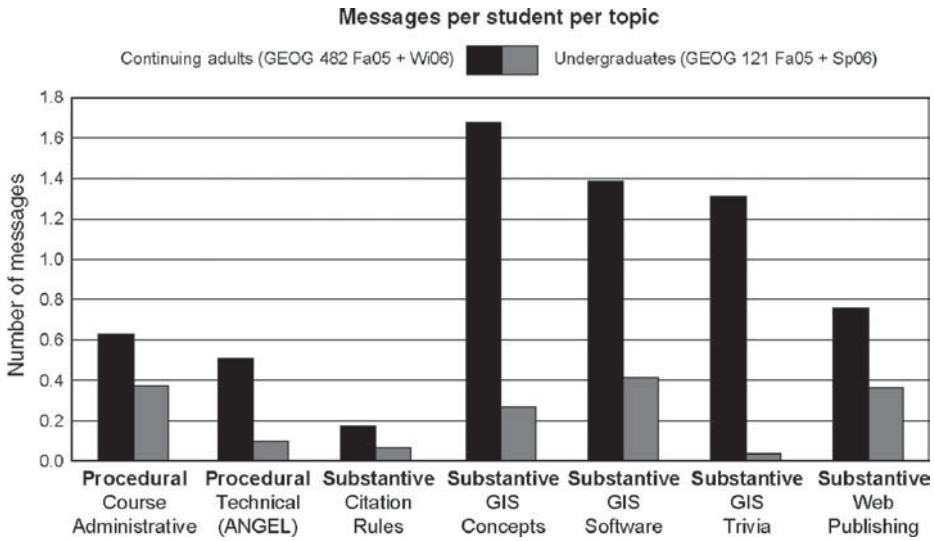

Figure 4. Results of qualitative analysis of the frequency of voluntary student communications by discussion category in separate sections of the online course.

cent). These results are consistent with Newstead *et al.*'s (1997) findings. The relatively little time undergraduates spent logged into ANGEL may be reflected in the poorer average scores they earned on open-book quizzes (79.4 per cent) relative to their older counterparts in GEOG 482 (89.6 per cent).

Although mean final exam scores are shown in Table 5, they are not comparable since for one section (GEOG 121) the exam was conducted as a closed-book proctored exam in a classroom setting while for the other section (GEOG 482) the exam took place online in an open-book format, just like the lesson quizzes. The rationale for these different examination modes was that undergraduates were more likely to copy responses from nearby classmates. Given that the final exam accounted for one-quarter of the course grade in both GEOG 121 and 482, differences in the mean final course grades are also artifacts of the different examination modes.

Table 5. Measures of student performance in separate sections of the online course

	Continuing adult professionals GEOG 482 Fa05 + Wi06	Undergraduates GEOG 121 Fa05 + Sp06
Project scores mean cumulative	86.8%	85.4%
Project three scores mean (max. 150)	130.9	132.2
Academic integrity interventions (% of students)	3.9%	9.9%
Lesson quiz scores mean cumulative	89.6%	79.4%
Final exam scores mean	88.5% (open book)	58.3% (proctored)
Final course scores mean (grades)	89.2% (A−)	80.8% (B)

Instructor Time Proportional to Student Activity

As explained in the previous section, the lead author maintained daily diaries of time and activities devoted to the two courses. In total, he recorded approximately 130 total hours attending to 178 students in GEOG 482 over two 10-week terms, and approximately 72 total hours attending to 101 students in GEOG 121 over two 15-week semesters. In both cases, the activity category that accounted for the most time was communications with students (66 per cent of total time in GEOG 482 and 45 per cent of total time in GEOG 121). Table 6 compares the amount of time per student the lead author invested as instructor of each class. The fact that he spent over 50 per cent more time communicating with older students in GEOG 482 is consistent with the fact that these students posted more than double the number of messages as their younger counterparts. These numbers also point to the instructor's tendency to react to student questions and comments rather than to proactively initiate conversations himself. In light of the number of students enrolled in the courses, this reactive approach may have prudent, but may also have had implications for the engagement, performance and attitudes of younger students.

In addition to the quantitative comparison presented in Table 6, results of a qualitative analysis of instructor communications appear in Figure 5. Notice that the number of instructor messages to GEOG 482 exceeds those sent to GEOG 121 students in every category except one: procedural questions about administrative issues including course policies. The difference in number of messages about GIS Concepts is particularly striking.

Older Students Significantly More Satisfied

Figure 6 compares cumulative frequencies of student responses to end-of-term surveys routinely administered to Penn State students. The two graphs on the left show the distributions of 138 ratings submitted by GEOG 482 students in response to the questions: (1) "rate the overall quality of this course" and (2) "rate the overall quality of the instructor". The two graphs on the right show the distributions of responses from 75 GEOG 121 students to the same two questions. The K–S test indicates that the differences between both pairs of distributions are statistically significant at the $p = 0.01$ level. Clearly, the younger students in GEOG 121 reported that they were significantly less satisfied with their class and the instructor than the older students in GEOG 482.

Table 6. Frequency of instructor communications with students in separate sections of the online course

	Continuing adult professionals GEOG 482 Fa05 + Wi06, $n = 178$	Undergraduates GEOG 121 Fa05 + Sp06, $n = 101$
Time devoted to communications (per student, minutes: seconds)	29:10	19:17
Message board replies (mean per student)	2.9	1.4
Email replies (mean per student)	3.0	1.2

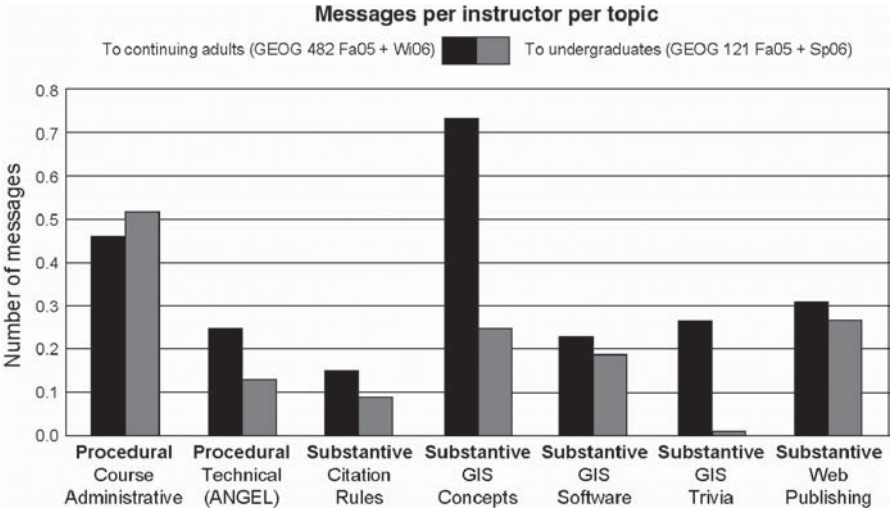

Figure 5. Results of qualitative analysis of the frequency of instructor messages to students by discussion category in separate sections of the online course.

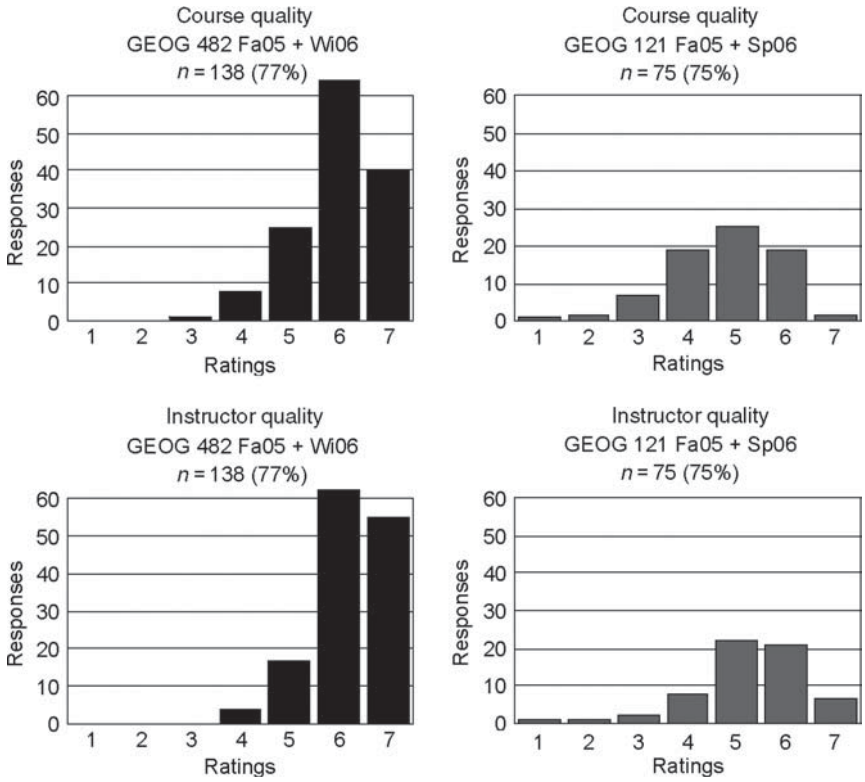

Figure 6. Results of student satisfaction surveys administered in separate sections of the online course.

Impact of Self-Reported 'Motivation'

Results presented to this point indicate that the younger students enrolled in GEOG 121:

- logged into class one-third less frequently;
- stayed logged in for about half as much time overall;
- participated in class communications at less than half the rate of older counterparts;
- were more likely to contribute procedural rather than substantive questions and comments;
- performed equally well in project assignments, but required three times the number of academic integrity interventions and
- were significantly less satisfied with the course and the instructor.

As noted above, the two cohorts differed not only in age, but also in their reasons for enrolling in the course. Nearly all of the continuing adult professionals enrolled in GEOG 482 enrolled with the expectation that the class (and the certificate and masters degree programs of which the class is a part) would help advance their careers. On the other hand, many of the undergraduate students in GEOG 121 enrolled only to fulfill an elective or general education requirement. Consequently, the proportion of GEOG 121 students who agreed or strongly agreed with the statement "I am highly motivated to do well in this course" in the February 2006 survey was markedly lower (67 per cent) than the older GEOG 482 students (90 per cent; see Figure 7). The K–S test confirms that the difference between the two distributions is statistically significant at the $p = 0.01$ level.

To what extent were observed differences in performance and attitudes of the younger students attributable to differences in self-reported motivation to succeed in the course? To address this question, we reviewed data associated with the subset of 28 GEOG 121 students who completed the course and who self-identified as being highly motivated.

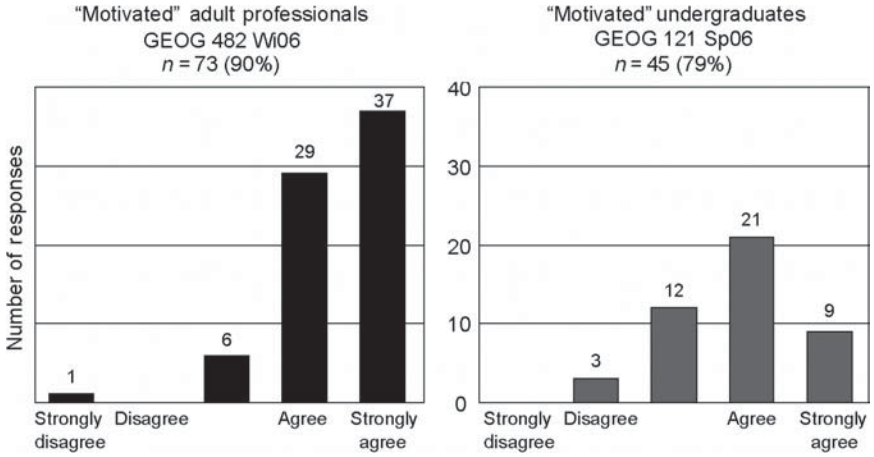

Figure 7. Responses to survey question "I am highly motivated to succeed in this course" administered in separate sections of the online course. Of 30 who agreed or strongly agreed, 28 completed the course and were included in subset studied in the following section.

Intrinsic Motivation Accounts for Some Difference

Table 7 compares the frequency and duration of logins to the ANGEL course section by the subset of 28 'motivated' undergraduates with the responses of the younger and older cohorts (as reported above). As a group, the 'motivated' undergraduates logged into class 35 per cent more frequently than their peers in GEOG 121, but still 13 per cent less frequently than older students in GEOG 482. The subset also stayed logged in for 25 per cent more time overall than their peers, but 37 per cent less than their older counterparts. These data indicate that self-reported motivation accounts for some but not all of the difference in the time-on-task between the two age cohorts.

Table 8 compares the mean number of message board postings and course mail messages contributed by the 28 'motivated' undergraduates with the data for the younger and older cohorts (as reported above). As a group, the motivated undergraduates contributed about one-third more postings than their peers in GEOG 121, but still only less than half as many as their older counterparts in GEOG 482.

Table 9 compares the mean performance on class assignments of the 28 'motivated' undergraduates with the younger and older cohorts (as reported above). As a group, the motivated undergraduates earned high scores for their project reports, but required as many academic integrity interventions as their peers in GEOG 121. Motivated undergraduates' quiz scores and final course scores and grades were more similar to their peers in GEOG 121 than to older students in GEOG 482. Once again, self-reported motivation accounts for some but not all of the differences in performance between the two age cohorts.

Interviews with 'Motivated' Undergraduates

To better understand undergraduate students' experiences in GEOG 121, we interviewed five students among the 28 'motivated' students. These students were interviewed in Summer 2006, after the semester had ended and grades were reported. Three of the five students were Geography majors for whom GEOG 121 was a degree requirement. Two others who majored in Information Sciences and Technology (IST) were able to count GEOG 121 credits toward their baccalaureate degrees, even though the course was not a required course in their program. Among other questions, interviewees were asked to "describe the kind of student you think would be most successful in Geography 121." The following statements are excerpted from interviewee's responses:

Table 7. Frequency and amount of student time-on-task by 'motivated' undergraduates in relation to continuing adult professionals and all undergraduates

	Continuing adult professionals GEOG 482 Fa05 + Wi06, 10-week courses	'Motivated' undergraduates GEOG 121 Sp06, 15-week course	Undergraduates GEOG 121 Fa05 + Sp06, 15-week courses
Logins per student per term	123	108	80
Hours logged in per student per term	56	35	28

Table 8. Frequency of voluntary student communications by 'motivated' undergraduates in relation to continuing adult professionals and all undergraduates

	Continuing adult professionals GEOG 482 Fa05 + Wi06	'Motivated' undergraduates GEOG 121 Sp06	Undergraduates GEOG 121 Fa05 + Sp06
Message board postings per student	4.2	2.5	1.9
Message board replies per student	4.1	0.9	0.6
Total	8.3	3.4	2.5
Mail messages initiated per student	2.0	0.9	0.9
Mail message replies per student	2.2	0.8	0.7

> Anyone with an interest in GIS and who can work on their own (Geography major #1).

> Someone that is very independent and keeps up with their work (Geography major #2).

> Someone willing to take time every day to read it in bits and pieces . . . someone who will read things you don't understand until you do (Geography major #3).

> definitely people that are in the major, and interested in it . . . students that are already motivated to do well in that course . . . (IST major #1).

> As long as someone was interested in it (IST major #2).

In addition to interest and intrinsic motivation, three of the five interviewees (the three geography majors, whose interest and motivation is to be expected) identified the ability to manage one's time and to work independently as key characteristics of successful students in GEOG 121. IST major #1 emphasized this further:

Table 9. Measures of student performance in separate sections of the online course

	Continuing adult professionals GEOG 482 Fa05 + Wi06	'Motivated' undergraduates GEOG 121 Sp06	Undergraduates GEOG 121 Fa05 + Sp06
Project scores, mean cumulative	86.8%	89.4%	85.4%
Project three scores, mean (max. 150)	130.9	137.4	132.2
Academic integrity interventions (% of students)	3.9%	10.0%	9.9%
Lesson quiz scores, mean cumulative	89.6%	82.0%	79.4%
Final exam scores, mean	88.5% (open book)	60.0% (proctored)	58.3% (proctored)
Final course scores, mean (grades)	89.2% (A−)	84.2% (B)	80.8% (B)

> With online courses you have to be a little more organized and self-motivated ... I can see how people not as organized can fall behind. [Online learning] forces you to be more organized and prioritize (IST major #1).

Data associated with the 'highly motivated' undergraduates considered above suggests that self-reported motivation accounts for some but not all of the differences in behaviors and attitudes observed between the younger and older cohorts in this study. Other factors related to differences in age may explain the remaining differences in how much time students devoted to their classes and how they felt about the experience.

As discussed above, one factor may be older students' superior study skills. As Velasek (2001) pointed out, older students tend to have better time-management skills than younger students, and therefore tend to have higher success rates in online courses. Responses to the midcourse survey administered to GEOG 121 and 482 students in February 2006 do not support Velasek's generalization, however. While only 38 per cent of GEOG 121 students strongly agreed with the statement "I have the self-discipline needed to complete assignments independently," only 45 per cent of older GEOG 482 students strongly agreed with the same statement. The K–S statistic revealed no significant difference in responses to this survey question between the two cohorts.

Other possible factors include the related professional experience that many GEOG 482 students brought to their student experience, unlike the undergraduate students in GEOG 121. We consider this possibility in the Discussion section. It is also possible that reading ability differed between the two groups and that difference affected student performance. Students who struggle to read may have devoted less time to their studies than those for whom reading is less of a chore. We did not investigate this possible difference but believe that it is worthy of further research.

What the foregoing analysis does establish unequivocally is that older students in GEOG 482 devoted substantially more time to both assigned and voluntary activities than their younger counterparts in GEOG 121, even when self-reported intrinsic motivation is taken into account. The association of greater time-on-task and more frequent interaction with greater satisfaction within the older GEOG 482 cohort is consistent with previous studies which sought to identify key factors that account for success in online courses (e.g. Swan *et al.*, 2000).

These observations beg the question of what, if anything, the GEOG 482 students gained from their greater investments of time and effort, beyond increased satisfaction? A second, two-part question is why even the 'highly motivated' younger students in GEOG 121 devoted less time and initiated fewer interactions than their older counterparts, and what might be done about it? We consider each of these questions in the following discussion.

Discussion

Did older students in GEOG 482 learn more than their younger counterparts by virtue of their greater engagement with class work? We cannot answer this question conclusively since our quasi-experimental research design did not include pre-tests. Even though older students had higher satisfaction with the class and the instructor, no appreciable difference was evident in older and younger students' performance on project assignments, the primary metric of student performance employed in both classes. One might conclude that

the extra efforts of older students in GEOG 482 were for naught. Younger students in GEOG 121 may have achieved similar results with less effort because class assignments required only relatively simple demonstrations of declarative knowledge. The additional time-on-task and interaction that the older students in GEOG 482 invested may be associated with their greater satisfaction, but we have no evidence that their extra efforts resulted in improved learning.

What evidence might we have discovered, however, had we measured explicitly the learning gains (if any) related to the substantive topics that older students in GEOG 482 discussed? Such measures of tacit knowledge gains are difficult to design and therefore are rarely deployed in studies of this kind. However, situated learning theory predicts that the older students, more than half of whom were already working in the GIS&T field, are likely to have been better prepared than their younger counterparts to relate course content to experience, and therefore may have been more likely to learn more through social interaction in the message boards. This expectation is consistent with the andragogical model's prediction that older students as a group are better prepared to leverage their experience and to thrive as independent learners. Future research designs that seek to illuminate the relationship between age, attitudes and performance of online students should incorporate metrics to evaluate gains associated with voluntary discussion.

There is an element of irony in the foregoing invocation of andragogy, since the class at the center of this study does not embody andragogical ideals. For instance, whereas andragogy "advocates learner control (at the very least, substantial input) over not only the objectives but also the learning strategies as well as evaluation procedures" (Rachal, 2002, p. 213), both GEOG 482 and 121 take a rather traditional pedagogical approach in which the instructor retains control over most educational goals and student activities. Furthermore, the classes' reliance on templated projects and multiple-choice quizzes and final exam "smack of 'schooling' and 'pedagogy' in its Knowlesian pejorative sense" (Rachal, 2002, p. 217). If the classes under study are pedagogical rather than andragogical in design and implementation, and if "the very nature of the adult in a learning setting demands, with few exceptions, andragogical or at least quasi-andragogical methods" (Rachal, 2002, p. 224), why then were older students in GEOG 482 significantly more satisfied with their experience than their younger counterparts in GEOG 121?

One factor may be the fact that with few exceptions GEOG 482 students were enrolled in only one class, while GEOG 121 served full-time undergraduate students who enrolled in four or more classes at a time. GEOG 482 may have been a somewhat novel experience for its students—a welcome distraction from the rigors of their full-time jobs and other adult responsibilities. Younger students may have been less enthusiastic and more critical because GEOG 121 was 'just another class', even if it was for most of the students their first online class.

A more important factor, we believe, was the positions of GEOG 482 and 121 in their respective programs of study. As mentioned above, GEOG 482 is the mandatory orientation course in both the 11-credit post-baccalaureate certificate program and the 35-credit professional masters degree program. GEOG 482 is the first formal online class for nearly all enrollees. Class design objectives include allaying students' worries about online learning. In our case, familiar instructivist pedagogy has proven effective in reassuring anxious students that they can count on instructors to guide and provide feedback about their progress through the class. So while an instructor-centered pedagogical approach is inappropriate for later, more advanced classes in the certificate

and masters programs, experience has shown it to be highly satisfactory for this initial orientation class [See King (2008) and Detwiler (2008) for discussion of two advanced classes]. In this regard, our approach is consistent with McClusky *et al.* (2007, p. 87), who conclude that "pedagogy–andragogy represents a continuum from teacher-directed to student-directed learning and that both approaches are appropriate with children and adults, depending on the situation."

The position of the online version of GEOG 121 in Penn State's undergraduate curriculum also helps to explain why the younger students it attracts tend to devote less time to their studies and to voluntary class activities than their older counterparts in GEOG 482. As explained above GEOG 121 is required only for the Bachelor of Science degree in geography and a few other degree programs; for most other undergraduates it is an elective class that partially fulfills the University's social science general education requirement.

While Penn State defines a 'credit hour' as the equivalent of 40 hours of student activity in a semester (Faculty Senate, 2004), it's common knowledge that students expect to devote less time to large-enrollment general educational classes than to smaller, more advanced classes that pertain directly to their intended degrees and subsequent careers. Gibbs (1999) observed that "although [U.S.] instructors may expect students to study for more than two hours out of class for each hour in class . . . they actually spend only between 0.3 and 1.0 hours." Furthermore, Garcia and Qin (2007) presented evidence that younger college students (21–25 years), unlike their older counterparts (36 years and older), generally expect that online classes will require less time than face-to-face classes. In the context of this study, we conclude that undergraduate students in the online version of GEOG 121 devoted less time to their studies because their approach to the experience was determined by an overriding concern about economy of effort.

Insufficient time-on-task is a crucial problem. Although our research design failed to illuminate differences in learning gains between the two cohorts, there is little doubt about the association between learning and effort. Chickering and Glamson (1987) included "emphasizing time on task" among their well-known seven principles of good practice in undergraduate education. In McKeachie's venerable *Teaching Tips*, Gibbs (1999) stated that ". . . planning a course so that students spend enough time tackling the necessary learning activities is one of the most important things teachers can do." Similarly the US National Research Council's Committee on Developments in the Science of Learning concludes that "in all domains of learning, the development of expertise occurs only with major investments of time" (Bransford *et al.*, 2000, p. 56).

Our analysis shows that the cohort of older students (median age 34) was significantly more satisfied with the online class than the cohort of students who were 15 years younger. Fifteen years from today, will students like those who enrolled in GEOG 121 be satisfied with an online education experience like GEOG 482? Or will age-related differences in approaches to e-learning, and learning in general, persist? And what do e-educators need to do to effect greater engagement by younger students? Mabrito and Medley (2008) pointed out that 'Net Generation' students tend to have markedly different learning styles than the Baby Boomers who make up a large portion of higher education faculty:

> . . . while N-Gens interact with the world through multimedia, online social networking, and routine multitasking, their professors tend to approach learning linearly, one task at a time, and as an individual activity that is centered largely around printed text (p. 1).

The distinctive ways in which many younger students approach learning reflect the cyberculture in which they are immersed. Vaidhyanathan's (2008) exhortation about the myth of generations notwithstanding, the culture traits of younger students seem likely to persist, for the same reasons that even technically literate Baby Boomers (like the lead author) tend to retain the characteristics of digital immigrants.

While mulling this study's preliminary results, the lead author attended a keynote address in which media scholar Henry Jenkins presented an intriguing case for the effectiveness of *play* in, and the relevance of popular culture to, education (Jenkins, 2006). In the discussion period after the talk, the lead author shared his impression that college students tend to be adept at using information and communication technologies to entertain themselves and to socialize, but they seem much less able to leverage technology for the hard work of learning. Jenkins responded by questioning what he considered to be the "puritanical distinction" between work and play. Seconding this view, Mabrito and Medley (2008, p. 2) argued that "[t]he spaces where N-Gen students construct a social identity, communicate with their peers, and interact with other media should not be dismissed as venues for mere entertainment or social acceptance".

The media and communications tools that many younger students in the US use routinely in those spaces are quite unlike the learning management system in which GEOG 121 and 482 were implemented at the time of this study. As Hartmann *et al.* (2005, p. 6.8) demonstrated, students who are used to being in touch with friends continuously by phone or instant messaging tend to be disappointed by the "lack of immediacy" and slow response times of their online courses and instructors. Older students, like their instructors, are more likely to be satisfied with email responses that arrive within 24 hours. The younger US students that Hartmann *et al.* (2005, p. 6.9) observed tended to feel "that the interaction mechanisms designed by their instructors were much less adequate than their personal technologies."

One way to elicit greater engagement among younger students like those enrolled in GEOG 121, therefore, may be to adopt communication technologies and customs with which 21-year-old US students are likely to be most familiar. An award-winning educator at our institution attracts and retains approximately 1000 undergraduate students each semester—most in online classes—in part because of his reputation for answering student calls on a dedicated mobile phone until 11 pm. Another highly responsive and popular colleague was the subject of a front-page story in the *Chronicle of Higher Education* entitled "The 24-Hour Professor" (Young, 2002). Whether many other instructors are prepared to adopt dedicated phones and instant messaging to address students' concerns at their convenience, in place of email replies issued at the instructors' convenience, is questionable. The lead author—who taught the classes investigated in this study—is admittedly skeptical in light of implications for workload and lifestyle. More likely, perhaps, is that the practice of online teaching will evolve as today's young adults replace retiring faculty members as they reach retirement age. No doubt the new cohort of university teachers will also confront perplexing traits and expectations of a new generation of 'neomillennial' learners who come of age steeped in immersive virtual environments (Dede, 2005).

Conclusion

The adage "youth is wasted on the young" (attributed variously to George Bernard Shaw and Oscar Wilde) connotes a bemused, mildly disapproving and slightly envious

assessment of a younger generation by an older observer. Among the outcomes of the action research reported here is the lead author's realization that his approach to teaching younger US adults online, and the results he achieved, reflect the same sentiments that Shaw and/or Wilde expressed. We characterize that approach as *reactive* in the sense that, in general, the instructor expected to respond to student inquiries and discussions rather than to initiate such interactions regularly. The data presented above demonstrate that the reactive approach was satisfactory for older students whose professional experience within the subject domain prepared them to initiate substantive comments and questions, and whose life experience prepared them to succeed as independent learners. The relative inexperience of younger students in US higher education seems to demand a more *proactive* approach in which instructors initiate interactions meant to elicit levels of student engagement comparable to what occurs more spontaneously within older cohorts. Online educators who aim to earn high levels of satisfaction among younger students may also need to adopt the communications technologies and customs such students use routinely, rather than those afforded by the current generation of learning management systems.

The implications of these approaches on faculty workload should lead educators and administrators to expect online classes and programs serving traditional college-age students in the US to be more demanding and more expensive to operate than online classes and programs for older adults. More fundamentally, this study has produced evidence in support of the assertion that younger learners approach formal educational experiences differently than older students. Their relative inexperience in subject domains, in real-world applications and in self-directed learning conspire to undermine younger students' readiness to thrive in online learning environments such as the one described above. On the other hand, older students' experience, mature study habits and enthusiasm prepare them to construct learning experiences that are fulfilling to both students and instructors. While older instructors may complain with some justification that online learning is wasted on the young, younger students may fairly counter that online teaching is an opportunity not to be wasted on the old.

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Notes

[1] The lessons are now available as an open educational resource at http://natureofgeoinfo.org

[2] PERL is an open source, cross-platform programming language that provides comprehensive string handling functions that makes it especially useful for processing text data. Additional information is available at http://www.perl.org

[3] Turnitin.com is a commercial plagiarism-detection service that compares the textual content of digital documents uploaded by authorized instructors and/or students with the content of documents uploaded previously or published in the Web.

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