

Online Education in Computer and Digital Forensics: A Case Study

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Abstract

Computer forensics is a relatively new, but growing, field of study at the undergraduate college and university level. This paper describes some of the course design aspects of teaching computer forensics in an online environment. The learning theories and pedagogies that provide the guiding principles for course design are presented, along with specific issues related to adult education. The paper then presents a detailed description of the design of an introductory computer forensics course, with particular attention to the issue of hands-on assignments in the online environment. Finally, a small study about the efficacy of the online courses is presented.

1. Introduction

The study of computer forensics and digital investigations is a relatively new discipline in undergraduate education. More recently, some colleges and universities are teaching this subject matter in an online delivery mode.

Champlain College is a small college in Burlington, Vermont, with roughly 1800 traditional undergraduate students and nearly a thousand online and continuing education students. The college offers A.S., B.S., and M.S. degrees in over 30 programs in an environment that balances liberal studies and a practical education.

Answering the needs of the local Internet Crimes Against Children (ICAC) Task Force, as well as several national studies [1, 2, 3], the college offered its first computer forensics class in the Fall, 2002 semester. Co-taught by the author and the coordinator of the Vermont ICAC, the success of the course and additional analysis caused us to believe that a curriculum focusing on digital investigations would fill a national need. In the Fall, 2003, the Computer & Digital Forensics (C&DF) undergraduate degree and

academic certificate programs officially rolled out, and the Computer Forensics I course was made available online; by Fall, 2004, all courses in the C&DF curriculum were available online [4]. (The C&DF course curriculum can be viewed on the Web at <http://digitalforensics.champlain.edu>.)

Section 2 of this paper will discuss the pedagogic foundation of online courses, with a particular focus on the C&DF curriculum and adult learners. As a specific example, Section 3 will discuss the online version of the introductory computer forensics course, with a particular focus on how hands-on exercises are provided in the online learning environment (OLE). Section 4 will present a small study comparing student performance in online and on-campus C&DF courses. Section 5 will provide some concluding comments.

2. Online education

Champlain College has been offering courses online since about 1993. Although the college has been using the WebCT learning management system (LMS) since the late-1990s, this paper will not be a critique of the product. This section will, instead, present the generic issues related to OLEs and online course pedagogy.

2.1. The online learning environment

Online courses provide students with access to educational opportunities that might otherwise be locked out due to their work or family schedule, geographic location, or other reasons. At their best, online classrooms provide a virtual experience that is comparable to -- albeit different than -- the traditional classroom; at it's worst, it is a modern-day correspondence course. And somewhere in-between is Web-based, self-paced courses.

Champlain College's online courses provide an asynchronous, virtual classroom. In this context, *asynchronous* alludes to the fact that classes do not

regularly meet at a given place and time. Nevertheless, these classes have the same syllabus, schedule, and rigor as an on-campus course.

The college's online classes have essentially the same course syllabus as their on-campus counterparts. This means that they are taught on the same traditional 15-week semester as the on-campus version, and have the same assignments, projects, and tests. Most importantly, the online and on-campus sections have the same learning objectives.

The LMS provides many tools for communication, including a threaded discussion forum allowing a student to post a comment for the entire class (or group) as well as an e-mail facility that allow message exchange between a student and the instructor, or between students. A chat facility allows real-time (*synchronous*) class or group meetings. A shared whiteboard allows a group from the class to make drawings and/or mark-up a diagram so that all members can see the virtual conference room.

In some ways, the virtual classroom has some distinct advantages over the traditional classroom because of the communication capability. First and foremost, the online environment can allow more students to get involved in more class discussions because of its very asynchronous nature. Some students do not respond to classroom discussion in the on-campus environment because they do not like having to speak publicly and think out loud in front of their peers. In the online classroom, they have time to think and create their response to the comments of others, and have time to post a response hours or days after the original comment was made. In fact, most online instructors require some level of participation in discussion so that all students are involved and engaged in the class, something that may not happen as often in an on-campus class.

The broad communications capabilities of the online LMS also provide enhanced one-on-one sessions between student and teacher, support for group activities, and better mentoring opportunities than is generally possible in the traditional classroom. Given the practical limitations of synchronizing the schedules of students and instructors, as well as the difficulty of an instructor keeping in close contact with every student, the OLE provides a classroom and college that is always open -- using a medium with which most individuals in this field are comfortable. Indeed, the communication and feedback is not real-time but students generally don't think twice about sending an e-mail or posting a discussion point at 2 a.m.

Online classes offer new opportunities for cheating and sideband communications outside of the LMS

because the very nature of the course means that all assignments and exams are "take home." Such behavior in online courses does not appear to be more prevalent than in traditional courses and can, in fact, be somewhat easier to detect in the writing-intensive online environment; a student who has difficulty stringing words together to form sentences in e-mail and discussion postings yet turns in an exam essay question or project paper worthy of a Pulitzer Prize is sure to be noticed by the course instructor.

In addition to an extensive suite of communications tools, the LMS provides an assignment tool through which assignments are delivered to the students and students submit the work. The assignment tool also provides a mechanism for the instructor to provide feedback and grades. Grades can also be automatically sent to the grade book, a feature that allows students to always know how they are faring in the class. Most students appreciate getting quick feedback on their progress.

The LMS also provides a mechanism for the delivery of self-tests and quizzes. Quizzes can be timed or untimed, and allow the possibility of automatic grading (which works well for multiple choice tests but is, in the author's opinion, much less effective for essay questions).

Finally, other features allow the power of the Internet to be integrated into the course. A list of Internet, college library, and other online resources, for example, can be built in to the course so that students can access tutorial and other adjunct materials. Remedial background information can be made available within the online class via links to tutorials and a student-run peer-tutoring service. Technical difficulties can be addressed via an online (and telephone accessible) helpdesk. All in all, there are many features to make the online classroom a complete learning experience.

2.2. Online course pedagogy

Irrespective of the power of the LMS, quality online courses come from content, course design, and material presentation. Proper educational pedagogies must also be followed. There is, however, no one good pedagogic model to follow in the design of any course or curriculum because students all learn differently and there has yet to appear a "Unified Theory of Learning" [5].

The design of the C&DF online courses are based on a variety of teaching pedagogies to reach a wide variety of students with different learning preferences, attempting to employ the best characteristics of each pedagogic model where the online environment could

leverage the greatest advantage [6]. A recurring theme is that all of the learning theories considered involve *active learning*, consistent with John Dewey's view that learning is an active, physical process [7, 8, 9]. Active learning enhances student performance, improves their general attitude towards the course and material, and helps to create a sense of community among students and faculty [10].

Five primary pedagogic models provided the guidelines for the design of C&DF online courses. The first is *constructivism*, Piaget's theory that cognitive structures are the building blocks of learning. Dewey and Vygotsky went further in describing *social constructivism*, the view that learning is a social activity requiring dialog between the student and his/her teachers and fellow students. Dewey's map analogy describes constructivism quite well; just as a map lays out a reference of the important landmarks of an unfamiliar geographic region which the map reader eventually fills in as their knowledge of the area improves, learners need a similar framework to understand new subject matter. Mental organization, then, is the key to this information storage and retrieval problem; students need to learn new cognitive structures *and* how to build the linkages between them. Therefore, constructivism assumes that students enter the classroom with *a priori* knowledge that affects how new knowledge is learned [9, 11, 12].

Constructivism is well-suited to an online teaching environment if the technology is used to support the tools of social discourse, such as e-mail, discussion forums, and chat facilities. Because of the lack of the social activity that would normally be found in an on-campus classroom, online instructors must be diligent and maintain what socialization they can using the tools at hand. Because students can view lectures at their own pace and as many times as necessary, they also feel more free to communicate with the instructor and other students at any time during the week.

The second model is that of *resource-based learning (RBL)*. The Internet can only be compared to the Library of Alexandria in terms of the raw amount of material on all subjects that is available. Unlike the Library of Alexandria, however, the Internet does *not* contain all known knowledge as many students believe; there is a lot of information -- and history -- that pre-dates the Internet and hasn't yet been digitized. Nevertheless, there is clearly an unprecedented volume of *current* and *new* knowledge accessible via the World Wide Web. Because of the timeliness of Web-based information, issues can be discussed based upon what is known at the moment rather than what was known at the beginning of the course term. Students, too, can look up items of information to augment any lecture

and do homework research. Finally, resource-based learning provides the instructor the opportunity to give students more interesting and relevant assignments, projects, and tests. Rather than limiting homework to the resources of the instructor or textbook, students can employ the Internet and other online resources to research relevant information and technical issues from an almost limitless technical reference library. RBL can adapt to the wide variety of students' learning styles, allow for the presentation of a number of views about an issue (requiring that students be instructed about how to apply critical thinking to the sites they visit and things that they read on the Web), encourage students' curiosity and investigative skills, and engage students in active learning [6].

The third pedagogic model is *collaborative learning*, following Dewey's observation that "[p]urposeful activity in social settings was key to genuine learning" [9, p. 56]. Group exercises are an excellent tool with which to teach team-building and communication skills, and to demonstrate the synergy that a group brings to problem solving. Students also generally gain a more thorough understanding of the subject matter, as they have to promote and defend their views while hearing other peoples' ideas. Students learn about roles and negotiation, which goes beyond the specific subject matter of a given course but is important to almost any discipline. The OLE is well-suited to group activities and collaborative exercises because the online environment obviates the need for face-to-face meetings and the inevitable scheduling conflicts that will arise; in fact, the online environment provides an excellent mechanism for group communication and groups can communicate with, and involve, the instructor, as necessary. Collaborative learning also promotes role-play simulation, where students see a variety of perspectives and learn much more than just the technology aspects of the assignment; this is learning on multiple planes [8, 13].

Problem-based learning (PBL) is the fourth model integrated into the online course design. "Ill-defined" problems or scenarios can be a fun and interesting way for students to synthesize and/or expand their knowledge, making abstract concepts more real. Because problems and scenarios tend to be real, relevant, and tangible, students usually are more motivated to work hard on these projects, often making many real-world assumptions that are applicable to them, further helping to improve their problem solving skills. PBL is well-suited to constructivism because students apply what they know to fully define the problem and find one of what may be many solutions to the stated problem; it is also well-suited to the online environment because bigger, more interesting

problems can be devised -- and solved using the Internet as an information resource [7, 13, 14].

The final pedagogic model is *narrative-based teaching (NBT)*, which means to teach by telling stories or sharing experiences. Because of the newness of the field, rapid changes in technology and the law, and the fact that every case is different, digital forensics benefits from narration and real-life "war stories" from instructors and students alike. NBT offers students a classroom experience larger than the text book by allowing a glimpse into the very real practical, technical, and ethical issues that arise every day in the field. Narration fits well in an online course because media tools such as audio, video, and animation can enable -- and enhance -- the story-telling. Providing a personal, real world context helps make a subject more memorable, interesting, fun, and engaging [6].

2.3. Online courses and the adult learner

Champlain College's online courses are specifically designed for adult learners, who are generally more mature and self-directed than traditional-aged students. Adult learners are best served with active, PBL methods, as suggested in the previous section. Essential course design elements include clearly-stated goals and objectives, learning modules that are as small as possible, and as high a level of interactivity between the instructor and other students as possible. Self-assessment tools such as quizzes and tests should also be employed as much as possible, both to keep the student on track and to provide frequent positive reinforcement [15, 16]. Students should also be advised up-front about the time expectations for the course as a whole, as well as per-assignment, to eliminate surprises that could deter success [17].

It is also important that courses be as technology-transparent as possible. Online courses should be developed so that content and other features are accessible by students employing a wide range of Web browsers, operating systems, or types of Internet connection, and technology requirements must be made known to the students prior to the beginning of the course. Course developers need to balance the computer power and network bandwidth required for each course so that it best suits the material to be delivered (e.g., HTML pages, streaming video, graphical image, audio, etc.) and the likely capabilities of the students, so as to assure the widest possible audience; an animation, for example, would better be delivered using Flash, a commonly-available browser plug-in, rather than a proprietary application that is browser-specific. A high level of computer

sophistication should not be a requirement for online courses and good technical support must be readily available to students to reduce frustration and ensure that they do not feel cast adrift [16, 18, 19, 20].

The bottom-line is that the OLE needs to emphasize content rather than technology. While course delivery modality and pedagogy certainly go hand-in-hand, the technology should enable rather than inhibit the experience. Indeed, quality of content is king; the mode of course delivery, no matter how effective, cannot save poor content (although poor technology can prevent access to excellent content). The online course Web site itself should be aesthetically pleasing and ergonomically sound. In addition to being attractive, the information on the site needs to be up-to-date and the pages easy to navigate -- and even entertaining. The content needs to be well-written and relevant, and use vernacular that is familiar to the audience; the perception of a site being boring, poorly organized, or confusing can have a devastating effect on the students taking the course [21]. The site doesn't need to be technologically fancy, however; simple HTML pages, text, and e-mail can be quite effective; students actually find it more important to be able to *read* a lecture and have the flexibility to set their own pace and time of study than to be able to *hear* a lecture and have face-to-face contact with the instructor and fellow students [19, 22].

2.4. Conclusion

The concepts offered in this section provide an overriding guide for the development of online courses in the C&DF program. The pedagogic background shows that online courses are not merely online correspondence courses, but designed based upon well-founded learning theories.

Course development teams are responsible for the creation and review of all C&DF courses. At the heart of the content preparation is a subject matter expert (SME). The SME may not have particular expertise in education or technology; the instructional technologists on the team work closely with the SME to find and develop appropriate media, assignments, delivery modes, and other items necessary to facilitate the online classroom.

Last, but certainly not least, creating pedagogically-sound online course materials is necessary but not sufficient for successful online courses; instructors must also know how to -- and want to -- teach in an online environment [23]. In addition to creating good online educational materials, online instructors are required to take a short course about online pedagogy and use of the LMS. Online instructors must also

believe that the online modality is a viable teaching mode and must specifically request an online teaching assignment.

3. Case study: Computer Forensics I

This section will describe *Computer Forensics I (FOR 240)* as an example of how the learning theories described here are put into practice in the C&DF curriculum. The first part will discuss the Web interface and course components and the second part will focus on hands-on exercises.

3.1. Course components

Figure 1 shows the homepage that students see when they logon to the FOR 240 class site. As shown, students can access all of the necessary classroom functions via this page; each instructor can configure their own homepage so as to emphasize the features that they will be making available. (A set of screen shots showing additional class functions can be found at <http://digitalforensics.champlain.edu/reference/WebCTshots.pdf>.)

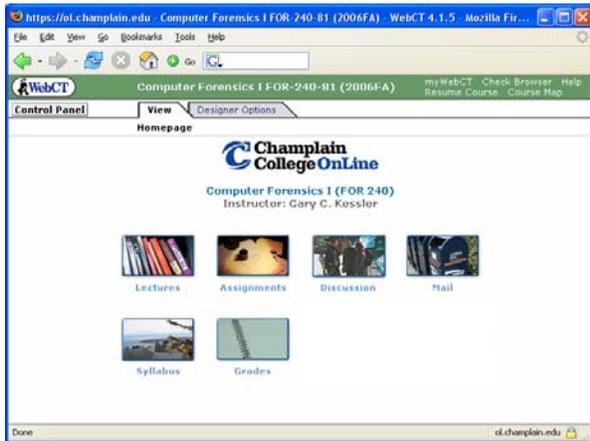


Figure 1. FOR 240 homepage.

The **Syllabus** link allows students to access the course syllabus and calendar. The syllabus lays out the course overview, learning objectives, general class policies, required and recommended texts, instructor contact information, etc. The course calendar lays out the week-by-week schedule, indicating the week's topic(s), required reading, homework and project assignments, due dates, etc. FOR 240 is a survey course required for C&DF, criminal justice (CJ), and Information Security majors; as such, it covers a broad range of topics ranging from the process of computer

forensics and digital investigations, and Constitutional law and search and seizure guidelines to the use of various computer forensics tools to network and cell phone forensics. (A detailed syllabus can be found at http://digitalforensics.champlain.edu/reference/for240_syllabus.html.)

The **Lectures** link brings students to the week's instructional materials. In most cases, the lecture page reminds students what they should be reading in the text and/or other reference, refers them to the assignment page, and indicates what the discussion requirements are for the week. A variety of technologies and media are used for the actual delivery of the "lecture." Students are generally provided with a PDF file containing the slides from a lecture that is provided in a voice-over-PowerPoint (VoPPT) format; i.e., they can see a PowerPoint presentation and hear the voice of the narrator just as they would in a typical classroom. VoPPT technology has proven to be very popular with students and content developers, alike. Students report that hearing the voice of the instructor humanizes the experience, provides one more "body language" factor (which is, by nature of the beast, often missing in online classes), and provides one more link between student and the instructor. (A sample VoPPT lecture can be found at <http://digitalforensics.champlain.edu/reference/for240-01-cyberforensics-1.html>.)

There may also be some reading attached to the lecture page, such as a late-breaking news story or relevant material that is not included in the PDF file. In some cases, a wholly different format is used. When software is being demonstrated, for example, a use of screen shots, Flash animations of screen captures, and step-by-step instructions are often employed. Some things -- such as the disassembly of a computer -- are better shown with a video, so these are provided online or distributed to students on a CD.

The **Assignments** link brings students to the page from where they can download homework assignments, projects, and tests. Since this page can be set to make assignments available at a given time and due at a given time, it is a good tool with which to enforce class policies and is an aid with which to focus student activities. The instructor can also download and grade submitted work, and provide feedback to the students, via this same page..

In this particular course, a "week" generally starts on a Saturday, with assignments for that week made available on Saturday morning and due ten days later. Students cannot turn in their assignments after the due date unless they get explicit permission from the instructor.

The **Discussion** link takes students to a page of threaded discussions. Instructors generally set up a new discussion thread for every week, providing a free-wheeling, open forum for any questions or comments pertaining to the week's subject matter. Part of the first week's assignment is to provide a short autobiography so that the instructor and students can get to know one another; many students use this opportunity to share a photo or an audio clip. It can be very useful during the term of the course to refer back to those personal introductions.

Special additional threads are defined, as needed. There is a standing assignment in FOR 240 called the Computer Forensics Topic-of-the-Week (TOTW). Given roughly eight to ten times during a traditional semester, the TOTW requires students to find some news item that is pertinent to the week's subject matter. In addition, each student has to present their topic to the class once per semester and lead a discussion about it; discussion threads for the public TOTWs, then, become student-led forums.

The **Mail** link is used to access the LMS' mail facility through which students can send mail to the instructor and/or other students. The mail capability greatly enhances group projects, providing a spam-and virus-free mail service that is always available and has no quota on the inbox.

Other resources, available through a pull-down menu, include access to a real-time chat capability, sharable whiteboard, helpdesk, additional online resources, etc.

3.2. Sample assignments

Computer forensics is a very hands-on discipline. While there is a fair amount of information which must be covered -- e.g., legal aspects, file systems, and network components -- most people learn this subject matter by being involved and engaged in activities. For this reason, FOR 240 employs PBL and hands-on exercises in as many assignments as possible.

As suggested earlier, group activities are greatly enhanced in an online environment. There are two small group projects in FOR 240. Since the class is generally comprised of C&DF majors as well as criminal justice (CJ) majors, the groups are purposely composed of students with different backgrounds to demonstrate that multiple types of expertise are required to solve real problems in the workplace. The problems are fashioned in such a way that the C&DF majors have a distinct advantage on part of the problem and the CJ majors have an advantage on the other, but the problem cannot be subdivided so that individuals can work alone and just plug the parts

together to form a solution; team members have to have interaction [24]. This interaction -- which does not require actual face-to-face time -- provides a distributed aspect to the assignment and, again, encourages learning on an entirely different plane than the course topic itself [11].

It is also important for the students to understand the legal aspects of this field and how to use online legal databases. In one class project, students are assigned a landmark case related to computer forensics or cybercrime and, from the case citation alone, need to find information sources so that they can prepare a one-page brief on the case. The brief is then shared with the class so that the entire class can reap the benefits by knowing about all of the cases that were assigned.

The next major issue is offering real hands-on problems. One criticism of online courses is that "online teaching of computer forensics cannot be done because a hands-on component is necessary." While it is certainly true that hands-on tasks are essential, there is nothing in an online class that prevents hands-on exercises from being performed. FOR 240, and its follow-on course, FOR 340 (Computer Forensics II), have many hands-on exercises employing several types of digital forensic software, including demo or evaluation copies of EnCase (Guidance Software), FTK (AccessData), Helix, Knoppix, ProDiscover (Pathway Technologies), and WinHex, as well as a plethora of other tools, some of which students themselves find on the Internet.

Students obtain course software from CDs distributed at the beginning of class or from Web sites provided in class assignments. Lecture material and/or assignments guide students through the use of the software while reinforcing the subject matter of the associated lecture. Our primary operating system is Windows because of the wide variety of available tools and the ubiquity of the platform; students are advised of this requirement at the beginning of class. The few students who have had difficulty running one program or another have posted queries to the class discussion forum and often get assistance from classmates before the instructor can respond.

There are a variety of exercises that are available from Internet sites that provide the basis for FOR 240 assignments. The Digital Forensic Research Workshop (<http://www.dfrws.org>) and the Honeynet Project (<http://www.honeynet.org>), for example, have a sufficient set of forensics challenges from which to create hands-on homework exercises; the author has modified two such exercises and used them in classes to teach students as well as other instructors. FOR 240 also employs a home-grown cell phone analysis

exercise. Images and evidence can be distributed in a variety of formats, including as a **.dd** file downloadable from the course Web site or as an **.e01** file on CD. Students can also create their own images from CDs, floppies, thumb drives, or other media.

Other hands-on exercises address issues related to network-based investigations. These exercises are even more conducive to an online environment because they require online activity, such as visits to informational Web sites (e.g., Sam Spade or DNSStuff), use of network-based tools (e.g., traceroute and packet sniffers), and use of network applications (e.g., Internet Relay Chat and instant messaging). Some students employ virtual computer software (e.g., VMware) in order to "build" additional computers for themselves with which they can experiment with other operating systems and virtual networks.

Indeed, hands-on exercises in the online environment cannot cover everything that we might like, particularly when it comes to employing forensics hardware tools. While students can certainly image a thumb drive to a hard disk, for example, it is logistically and economically difficult to arrange a scenario whereby students can physically image a hard drive to another, employ a hardware write-blocker, or access a cell phone. Nevertheless, the virtual classroom provides a rich potential for significant hands-on learning. Internships can also supplement classroom learning with more hands-on experience.

The C&DF program does not attempt to make students intimately familiar with any one given computer forensics tool. The program's philosophy is to focus on life-long learning and the process of digital investigations, rather than expertise with one version of any one product. Given that perspective, hands-on exercises are critically important to a student's understanding of what digital forensics is all about. What the online environment challenges is the assumption that hands-on exercises need to be done in an on-campus laboratory environment with an instructor or proctor hovering overhead. Indeed, we find our brightest stars are the students who go beyond the assignment and spend far more time in their own space working with the tools than they might if they could only access tools in a lab.

The hands-on assignments are supplemented by a series of writing assignments, including a brief based on recent cyber-related cases, analysis of legal case studies, and the periodic TOTWs. Students also have a final project that requires a literature review and class presentation. These assignments reinforce to students that written and verbal communication skills are equally important to technical skills; if one cannot communicate results of an examination to colleagues,

clients, judges, and/or juries, the work may well be wasted.

4. Efficacy of online education

In early 2006, the C&DF program performed a small study to determine if the learning objectives of the computer forensics courses were being met equally well in online and on-campus courses [25]. The study was performed for a number of reasons, not the least of which was to take a snapshot of whether the online program was performing as expected and to make any necessary mid-course corrections.

Four C&DF courses taught online and on-campus during the 2005 calendar year were studied; namely, Analysis of Digital Media, Computer Forensics I, Computer Forensics II, and White Collar Crime. The only way to know whether the learning objectives of a course are met is by assessing the students' grasp of the material through homework assignments, project work, and periodic testing; thus, the level of achievement of learning outcomes is a measurable attribute of instruction [26]. Tests and assignments are consistent across all of the sections of these particular courses, rather than leaving it up to individual instructors to develop their own assessment tools [27].

The students in each section of these courses were a combination of traditional, full-time undergraduates (generally C&DF or CJ majors) and non-traditional continuing education students (all adult learners, about half of whom were employees of a law enforcement or governmental agency). The study was based upon eight sets of final grades, representing those of all students in each of the four courses taught online and each of the four courses taught in-person; no distinction was made between individual sections or instructors.

Final grades from 176 students completing the courses provided the basis with which to test the study hypothesis, namely, that there is no significant difference in learning outcomes between the online and on-campus delivery mode. Since the study was testing whether students met a standard set of learning objectives at the end of the class rather than testing *how much* students learned, course pre-testing was irrelevant [27]. Post-course test scores were not employed because use of the course subject matter after the class ends is a more significant factor affecting retention than course delivery modality [28, 29].

A factorial (two-way) analysis of variance (ANOVA) was used to measure the interaction between the course and instructional delivery mode.

The final grade, normalized to a numeric scale (i.e., A=4.0, A-=3.7, B+=3.3, B=3.0, etc.), was the dependent variable, while the course and delivery mode were the independent variables. All statistical testing was performed at the 95% significance level (α).

Table 1 shows the summary of the factorial ANOVA tests of between-subjects effects. The significance level (p) for the interaction between course and mode is .062; since $p \geq \alpha$, there is no significant interaction between the two independent variables. The p -value for delivery mode alone is .242; since $p \geq \alpha$, delivery mode is not a significant factor in course grade. Finally, the p -value for the course alone is .020; since $p < \alpha$, the course itself is a significant factor in course grades. Taken together, the results suggest that the determining factor in final grades is solely the course itself. The data actually showed that while there is no significant difference between course outcomes in the two delivery modes, average grades in the online sections were slightly higher.

Table 1: Summary of factorial ANOVA tests of between-subjects effects (dependent variable: grade)

Source	df	F	Sig.	Partial Eta Squared
Course	3	3.374*	.020	.057
Mode	1	1.379	.242	.008
Course * Mode	3	2.491	.062	.043
Error	168	(.484)		

* $p < .05$

This study is certainly not a definitive one. First, because students freely register for courses and the fact that this study was intended to be completely non-invasive, it was not possible to randomly assign students to online or in-person sections. This might be a challenge to the internal validity of the data since students self-selected their course delivery method. However, this self-selection actually better represents the real world since students will, in fact, self-select based upon their learning preferences, course availability, work schedule, familiarity with computers, etc. In addition, self-selection may also result in students taking the delivery mode that provokes the least anxiety and, therefore, will allow a better focus on the course material.

In addition, the study made no correction for instructor differences in different sections of the same course, nor did it measure all aspects of student differences, such as age, maturity, motivation, etc. Nevertheless, the merit of this study is that it is based

upon empirical data without artificial controls, rather than based upon laboratory conditions [30, 31].

On a side note, student acceptance of the online courses has been very strong. Over the years, the college has seen growth in both the traditional and online students enrollments so that nearly half of the current C&DF majors are online students.

5. Conclusion

Online education is not right for all students, all instructors, and all subject matter. Nonetheless, online courses are an important vehicle for education and training in a wide variety of academic and practical disciplines.

This paper has described the provision of online education in digital forensics at Champlain College. While the program continues to evolve, improve, and grow, the online course delivery modality continues to play an ever-increasing role in our approach to computer forensics and digital investigation education.

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