COMPARATIVE LEARNING ANALYTICS APPLIED TO CREDIT AND NON-CREDIT CCNA COURSES DELIVERED ONLINE AND FACE-TO-FACE

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Abstract

This study is a continuation of the findings from an online hybrid non-credit distance learning research course developed by the Virtual Academy (VirtAC) [1] in the Department of Information Sciences and Technology (IST) [2] of the Volgenau School of Engineering (VSE) [3] at George Mason University (GMU). The development and research is funded by a grant from Cisco Systems [4].

An initial study [5] compared the effectiveness of traditional and social media marketing strategies in launching the first online non-credit 24-week Cisco Certified Network Associate (CCNA) course. Preliminary cost and conversion metrics from the first course supported the use of social media to market the course. The second study analyzed the results of the marketing activities for the second offering of the course that impacted retention and satisfaction.

This third study compares student performance enrolled in the same CCNA course delivered online as a non-credit certification offering compared to performance in online and face-to-face for credit courses offered at the same university.

The comparisons of hands-on laboratory scores and final scores across four modules for online and face-to-face classes for credit and non-credit offerings were done. We used two sample Welch t-Tests to compare the unbalanced groups. Results are mixed with the experimental non-credit online courses showing no significant difference in performance. The comparison of face-to-face and online for credit courses showed a significant positive difference for the online course. There were no significant differences between performance on the final test in three out of four modules when comparing the online non-credit courses with credit courses.

The findings support the effectiveness of the delivery of corporate technical training using hybrid online methods.

Keywords: Learning Analytics, Online Technical Course, Credit and Non-Credit Courses.

1 INTRODUCTION

This is the third paper that broadens the findings from an online hybrid non-credit distance learning research course developed by the Virtual Academy (VirtAc) in the Department of Information Sciences and Technology (IST) of the Volgenau School of Engineering (VSE) at George Mason University (GMU) to include learning analytics. Comparisons are made between the first and second offerings of the online 24 week non-credit course offered in an academic environment. Additional comparisons are made between the non-credit course and the credit online and face-to-face offerings of the same content. The development and research for the non-credit course is funded by a grant from Cisco Systems.

The first study compared the effectiveness of traditional and social media marketing strategies in launching the first online non-credit 24 week Cisco Certified Network Associate (CCNA) course. Preliminary cost and conversion metrics from the first course supported the use of social media to market the course [6]. In the second study the results of the marketing activities related to retention and satisfaction were analysed. Satisfaction with the online offering was high; retention for the 24 week course was impacted by the motivation of the non-traditional students [7]. As Aslanian [8] indicates, online distance courses expand learning opportunities for all students, but they are more likely to attract non-traditional students who have employment and family obligations that make attending traditional classes difficult.

There is little research on the retention or completion rate of non-credit classes with academic fees. There is research on the free massive open online courses (MOOCs). Selingo [8] discusses the experiment at San Jose State University with MOOCs that failed. In one of the MOOCs, just 25
percent of students passed; in another, only 50 percent passed, which was a much lower rate than for on-campus equivalents. The students enrolled in the CCNA experimental courses are working while taking the online class in preparation for taking the CCNA certification test. For this reason they can be categorized as non-traditional students.

This third study compares student performance in the CCNA course delivered online as a non-credit offering with student performance in credit online and face-to-face courses that have the same content and are offered at the same university.

According to Allen and Seaman in the annual report series initially known as the Sloan Online Survey [9] many chief academic officers rate the learning outcomes for online education to be “as good as or better” than those for face-to-face institutions. From the initial longitudinal report in 2003, approximately 57.2 percent of academic leaders reported that the learning outcomes in online are comparable to face-to-face. In the more recent report these leaders indicate online courses have grown to 77%. It is noted however, in the report that a consistent minority of academic leaders consider online to be inferior, especially in schools with no online offerings.

The growth in online offerings continues in both academic credit and non-credit offerings, as well as, in corporate education and training programs. Many employers have elected online education for the training and education of their employees. Learning and development professionals in the United States and Canada who are LinkedIn members responded to the question of what type of learning tools do you use to train employees. Many learning and development professionals in the United States and Canada who are LinkedIn members responded to the question of what type of learning tools are used to train employees. Of those responding 58% use online training developed in-house and 49% use online training delivered via an external provider. [10]

The need for academic studies using learning analytics to determine the effectiveness of online education continues. An ongoing area of research is the necessary conditions for student engagement in the learning environment including time on task and views. One variable in effective engagement is the instructor’s guidance and assistance [10]. In the experimental offering, the faculty member conducted a weekly synchronous session with students to provide assistance and structure in assisting them. This hybrid approach increases interactivity between the instructor and students. A high level of interactivity has been found in other studies to increase retention and performance in the online environment.

This is a case study that contributes to the literature related to the ongoing question: Are learning outcomes as measured by performance on comparable lab skills assessments and tests in both online courses and face-to-face comparable? Are there differences in performance between students in credit and non-credit courses? These comparative learning analytics and findings have value for both academic and corporate stakeholders involved in online education and training.

2 METHODOLOGY

Two offerings of the 24 week experimental online non-credit CCNA certification course were designed and delivered sequentially beginning in Fall 2015 and again in late summer 2016. The learning management systems (LMS) used for the online delivery are Blackboard and Cisco’s Netspace. These two LMSs are the source of the student data for the learning analytics used to assess the effectiveness of the experimental non-credit course, as well as, for the comparative data in the other credit courses. The credit courses were selected because they have equivalent content and are delivered in either a face-to-face or an online environment at the same institution.

The student performance on each of the course modules are analysed using assessment and lab scores. A two sample Welch t-Test was used to compare the unbalanced groups. The sample for the 24-week experimental courses was less than 10 students at the end of the classes. Due to the nature of the study, e.g. case study, the generalizability may be limited.

The student performance comparisons are between hands-on laboratory scores and final test scores across four modules for online and face-to-face classes in credit and non-credit offerings. A glossary that provides an explanation of the content of the modules and the related assessments is an attachment to the paper for readers with a more granular interest in the learning goals.

The hypothesis is that there are no significant differences in student performance between the online non-credit experimental offerings and credit online offerings of a technical course. A second hypothesis is that there are no significant differences in performance between online non-credit
offerings and credit face-to-face offerings of a technical course. A third hypothesis is that there are no significant differences in student performance between credit online and face-to-face offerings for Modules 1 and 2. A fourth hypothesis is that there are no significant differences in student performance between credit online and face-to-face offerings for Modules 3 and 4. Accepting the null hypotheses is consistent with the current expectations that online and face-to-face courses are equivalent. In addition, the credit and non-credit face-to-face and online courses are equivalent.

3 RESULTS

The findings are discussed and summarized in the following four tables:

Table 1. Comparison of Performance in Modules 1 and 2 CCNA Online Non-credit Course with Face-to-Face Credit Course

<table>
<thead>
<tr>
<th>Test/ Milestone</th>
<th>CCNA Online Non-credit Course Mean</th>
<th>Face-to-Face Credit Mean</th>
<th>95% Confidence Interval lower limit</th>
<th>95% Confidence Interval upper limit</th>
<th>p-value</th>
<th>Accept/ Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill Assessment 1</td>
<td>53.166</td>
<td>83.51</td>
<td>-58.475</td>
<td>-2.211</td>
<td>0.03865</td>
<td>Reject Null Hypothesis</td>
</tr>
<tr>
<td>Skill Assessment 2</td>
<td>77.25</td>
<td>69.688</td>
<td>-41.9</td>
<td>57.02</td>
<td>0.6755</td>
<td>Accept Null Hypothesis</td>
</tr>
<tr>
<td>Netacad final 1</td>
<td>82.209</td>
<td>91.786</td>
<td>-17.31</td>
<td>-1.8449</td>
<td>0.01839</td>
<td>Reject Null Hypothesis</td>
</tr>
<tr>
<td>Netacad final 2</td>
<td>82.583</td>
<td>92.225</td>
<td>-27.697</td>
<td>8.414</td>
<td>0.2382</td>
<td>Accept Null Hypothesis</td>
</tr>
</tbody>
</table>

In Table 1, we compare the performance in CCNA non-credit distance learning course (Modules 1 & 2) with the mandatory face-to-face credit course (341) that covers the same modules. For this specific comparison, we compare Skill Assessment 1 & 2 and Netacad final 1 & 2. Clearly the means show that the face-to-face credit course has a higher mean than the CCNA course across all assessment methods except for Skill Assessment 2. Furthermore, the t test shows that for two results (Skill Assessment 1 and Netacad final 1) the p-value is less than 0.05 and hence we reject the null hypothesis that the mean of two groups are statistically different. In the second part of the course, students' performance as measured by the standard skill assessment and final was not significantly different between delivery methods. This finding is consistent with earlier research done by Xu and on performance gaps in online courses. Specifically students improved in performance after they become familiar with the navigation of the learning management applications and systems. Further the online course is a hybrid offering with weekly synchronous sessions conducted by the online instructor designed to enable successful completion of the lab and learning activities for the course. The hybrid design facilitates instructor and student interaction in the distance course. Interactivity in online education is a process measure in the research and literature review that has been linked positively with motivation, as well as, retention or completion of the course.

Table 2. Comparison of Performance in Modules 3 and 4 CCNA Online Non-credit Course with Face-to-Face Credit Course

<table>
<thead>
<tr>
<th>Test/ Milestone</th>
<th>CCNA Online Non-credit Course Mean</th>
<th>Face-to-Face Credit Mean</th>
<th>95% Confidence Interval lower limit</th>
<th>95% Confidence Interval upper limit</th>
<th>p-value</th>
<th>Accept/ Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill Assessment 3</td>
<td>53.67</td>
<td>72.615</td>
<td>-66.251</td>
<td>28.353</td>
<td>0.327</td>
<td>Accept the null hypothesis</td>
</tr>
<tr>
<td>Skill Assessment 4</td>
<td>66.25</td>
<td>85</td>
<td>-73.521</td>
<td>36.021</td>
<td>0.3613</td>
<td>Accept the null hypothesis</td>
</tr>
<tr>
<td>Netacad final 3</td>
<td>89.71</td>
<td>96.67</td>
<td>-17.01</td>
<td>3.11</td>
<td>0.1413</td>
<td>Accept the null hypothesis</td>
</tr>
<tr>
<td>Netacad final 4</td>
<td>90.93</td>
<td>97.24</td>
<td>-16.04</td>
<td>3.42</td>
<td>0.161</td>
<td>Accept the null hypothesis</td>
</tr>
</tbody>
</table>
In Table 2, we compare student performance in CCNA distance learning course (Modules 3 & 4) with the mandatory or for credit face-to-face offering of the course (445). For this specific comparison, we are comparing Skill Assessment 3 & 4 and Netacad final 3 & 4. The t.test shows that the p-value is greater than 0.05 for all the assessment methods and we cannot reject the null hypothesis that the means of two different groups are not statistically different. This finding is consistent with the literature and research that shows that equivalent learning in well-designed online courses occurs. The contribution of this study is the finding that there is no significant difference in performance when a mean comparison of performance in equivalently designed credit and non-credit offerings of a technical face-to-face and distance learning course is done.

Table 3. Comparison of CCNA Modules 1 and 2 Online Credit Course with Face-to-Face Credit Course

<table>
<thead>
<tr>
<th>Test/Milestone</th>
<th>DL Credit Class Mean</th>
<th>F2F Credit Class Mean</th>
<th>p-value</th>
<th>95% Confidence Interval lower limit</th>
<th>95% Confidence Interval upper limit</th>
<th>Accept/ Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill Assessment 1</td>
<td>82.2</td>
<td>61.2</td>
<td>0.001514</td>
<td>8.366</td>
<td>33.76</td>
<td>Reject Null Hypothesis</td>
</tr>
<tr>
<td>Netacad final 1</td>
<td>92.9</td>
<td>60.8</td>
<td>3.313E-12</td>
<td>25.37</td>
<td>38.9</td>
<td>Reject Null Hypothesis</td>
</tr>
<tr>
<td>Midterm</td>
<td>76.9</td>
<td>76.3</td>
<td>0.8704</td>
<td>-6.201</td>
<td>7.311</td>
<td>Accept Null Hypothesis</td>
</tr>
<tr>
<td>Skill Assessment 2</td>
<td>57.3</td>
<td>45.1</td>
<td>0.116</td>
<td>-3.1</td>
<td>27.62</td>
<td>Accept Null Hypothesis</td>
</tr>
<tr>
<td>Netacad final 2</td>
<td>93.8</td>
<td>64.3</td>
<td>2.745E-07</td>
<td>19.77</td>
<td>39.2</td>
<td>Reject Null Hypothesis</td>
</tr>
<tr>
<td>Lab work</td>
<td>90.8</td>
<td>93.5</td>
<td>0.4398</td>
<td>-9.63</td>
<td>4.24</td>
<td>Accept Null Hypothesis</td>
</tr>
</tbody>
</table>

In Table 3, we compare the credit distance learning (DL)(341) course with the credit face-to-face course (F2F). For this specific comparison, we are comparing Skill Assessment 1 & 2, Midterm, Labwork and Netacad final 1 & 2. Clearly the means show us that 341 DL course has a higher mean than 341 F2F course across all assessment methods except for the lab work, which may be attributed to direct help being given instantaneously to students taking the course in class. Furthermore, the t.test shows that p-value is less than 0.05 for assessment methods such as Skills Assessment 1, and Netacad final 1 and 2 which shows that the mean of the two different groups are statistically different across these assessment methods.

Table 4. Comparison of Performance in Modules 3 and 4 CCNA Online Non-credit Course with Face-to-Face Credit Course

<table>
<thead>
<tr>
<th>Test/Milestone</th>
<th>Credit DL 445 Mean</th>
<th>Credit F2F 445 Mean</th>
<th>p-value</th>
<th>95% Confidence Interval lower limit</th>
<th>95% Confidence Interval upper limit</th>
<th>Accept/ Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill Assessment 1</td>
<td>72.615</td>
<td>28.62</td>
<td>0.01296</td>
<td>10.795</td>
<td>77.18</td>
<td>Reject Null Hypothesis</td>
</tr>
<tr>
<td>Netacad final 1</td>
<td>89.23</td>
<td>78.83</td>
<td>0.3576</td>
<td>-12.79</td>
<td>33.58</td>
<td>Accept Null Hypothesis</td>
</tr>
<tr>
<td>Skill Assessment 2</td>
<td>66.785</td>
<td>66.62</td>
<td>0.9903</td>
<td>-27.02</td>
<td>27.345</td>
<td>Accept Null Hypothesis</td>
</tr>
<tr>
<td>Netacad final 2</td>
<td>76.407</td>
<td>89.97</td>
<td>0.2769</td>
<td>-39.0365</td>
<td>11.90087</td>
<td>Accept Null Hypothesis</td>
</tr>
</tbody>
</table>

In Table 4, we compare the credit offerings in-person face-to-face course (F2F) with credit distance learning (DL) 445 course. For this specific comparison, we are comparing Skill Assessment 1 & 2, and Netacad final 1 & 2. Clearly the means show us that 445 DL course has a higher mean than 341 F2F course across all assessment methods except for the Netacad final 2. Furthermore, the t.test shows that p-value is greater than 0.05 for almost all the assessment methods except Skill Assessment 1. It clearly proves that the means of the two groups are not statistically different. This indicates comparable performance between students enrolled in credit face-to-face and credit distance learning courses.
4 CONCLUSIONS

When comparing student performance in the experimental online non-credit course with the performance of students in the face-to-face credit course environment, students in the online course upon completion of the first module, performed equally with the face-to-face students in the subsequent three modules. This demonstrates that upon completion of the first module and having adapted to the LMS systems and the instructional style and design, students were able to perform effectively in the online non-credit learning environment. This finding is of high value to non-traditional students who often need to complete technical courses in an online environment. Further this finding is of importance to employers, because of the dynamic growth in the delivery of training and education using the online environment.

When we compared performance in the online and face-to-face environment for credit courses, results were similar to the above. The mean values for the distance learning were higher than the face-to-face class and in several assessments across modules 1-4 in Tables 3 and 4, the means were significantly higher for the online classes. These comparisons reinforce the initial finding, because in the traditional academic environment distant learning performance was equal to or greater than the performance in the face-to-face classroom. A comparison of the motivational differences for students in an online or face-to-face for credit course includes the level of stress associated with completion of labs and assessments in the face to face environment with an instructor being present. On one hand the assistance real time of having a faculty member presence is a positive factor; however, in an assessment environment students may experience more stress than those in an online environment.

These positive learning analytics within a non-credit 24 week course provide a framework for additional research related to student motivation and instructional processes that enable a greater number of students to effectively complete online non-credit courses. As the growth in the number of students taking online non-credit courses continues, this area of research promises a favorable return on time and investment for the individual, employer and the greater economy.

REFERENCES

[2] Information Sciences and Technology Department: http://ist.gmu.edu/
GLOSSARY

CCNA Common Learning Modules for Non-Credit and Credit Courses and Performance Measures

Skill Assessment 1

Introduction to Networks

Introduction to Networks that introduces the architecture, structure, functions, components, and models of the Internet and computer networks. The principles of IP addressing and fundamentals of Ethernet concepts, media, and operations are introduced to provide a foundation for the curriculum. Describes the architecture, components, and operations of routers and switches in a small network as well as how to configure a router and a switch for basic functionality.

Skill Assessment 2

Routing & Switching Essentials

By the end of the course, students will be able to build simple LANs, perform basic configurations for routers and switches, and implement IP addressing schemes. Students will also be able to configure and troubleshoot routers and switches and resolve common issues with RIPv1, RIPv2, single-area and multi-area OSPF, virtual LANs, and inter-VLAN routing in both IPv4 and IPv6 networks.

Description Module 1 and 2 of CCNA Group (341)

This course focuses on the primary aspects of data communications networking, including a study of the Open Systems Interconnection (OSI) and Internet models. Students start at Layer 1 with the study of various Layer 1 interface and cabling configurations. They construct and test various cables with connectors. Moving up the OSI layers, students will focus on IP network addressing, network design, and enhanced hands-on router and port configurations. Switch configuration like creation and management of VLANs are covered. They also learn security protocols and do static routing, RIPv2, and OSPF configurations. Concentration on layers 4 through 7 include studying TCP, UDP, data reliability, and error correction methods, on the ladder to the FTP, HTTP, SMTP, DNS, and TFTP protocols of Layer 7. Half of this course entails lab work where students design networks, configure routers and switches, engages in implementation and testing of networking devices.

Skill Assessment 3

Scaling Networks

Describes the architecture, components, and operations of routers and switches in a large and complex network. Students learn how to configure routers and switches for advanced functionality. By the end of this course, students will be able to configure and troubleshoot routers and switches and resolve common issues with OSPF, EIGRP, STP, and VTP in both IPv4 and IPv6 networks. Students will also develop the knowledge and skills needed to implement DHCP and DNS operations in a network. Skill Assessment 4

Skill Assessment 4

Connecting Networks

This discusses the WAN technologies and network services required by converged applications in a complex network. The course enables students to understand the selection criteria of network devices and WAN technologies to meet network requirements. Students learn how to configure and troubleshoot network devices and resolve common issues with data link protocols. Students also develop the knowledge and skills needed to implement IPSec and virtual private network (VPN) operations in a complex network.

Description of Module 3 and 4 of CCNA Group (441):

This course focuses on Layer 2 and 3 of the OSI model and WAN technologies. Frame Relay and ISDN, complex router configurations, Network Address Translation (NAT), Dynamic Host Configuration Protocol (DHCP), and study of Network Management Systems available for Data Communications Networks. We will also cover Single and Multi Area OSPF and EIGRP routing protocols.
**Netacad 1-4 Exams:**

These are timed online assessments where there are multiple choice questions based on the curriculum which consists of 4 courses. They are Intro to Networks, Routing & Switching Essentials, Scaling Networks, and Connecting Networks. The first two courses prepare students for the CCENT certification exam, and modules 3 and 4 along with 1-2 prepare them for the CCNA certification exam.