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Development of Assessment Plan for Online Thermo-Fluid Science Courses

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Abstract
Due to the flexibility and accessibility aspects, online learning is in high demand. Many higher education institutions offer courses, certificates, and degree programs partially or fully online. Educators have been redesigning their courses for the online learning environment. Course management systems such as Blackboard, Moodle, and many others are adopted by higher education institutions to provide a platform to teach online courses. Transforming course contents from a traditional course to an online course can be challenging, as courses do have hands-on components such as laboratories, projects, and in-class exercises. Many educators shared their experiences in designing and developing online courses and provided approaches they employed when transforming an in-class course to an online course. However, it is also important to measure the effectiveness of the online courses and determine the proper learning activities for the online environment. Although using only course grades to assess the effectiveness of online courses may be adequate, it may not necessarily provide an in-depth assessment of each chapter/topic. The authors suggest to collected and assessed homework and exam grades for both in-class and online settings over multiple semesters. This will help the instructors to identify the topics, chapters, or modules students may have difficulty in general. This paper provides the development of an assessment plan to measure the effectiveness of online Applied Fluid Mechanics and Applied Thermodynamics courses that are offered in the Mechanical Engineering Technology Department at Farmingdale State College.
Keywords: Fluid Mechanics, Online Education, Thermodynamics, Thermo-Fluid Sciences

1. Introduction

Online education has become a popular pedagogy in recent years (Yilmaz, Golpek and Nissenson). Online course settings not only are able to offset the growing enrollment, they also offer several advantages over the traditional in-class teaching. One of the main advantages is the flexibility and accessibility of course materials. Both traditional and non-traditional students can have the flexibility of learning the materials at their own time that do not conflict with their day-to-day activities (Broadbent and Hall). In addition, online course settings allow students to learn the course materials at their own pace without being forced to follow the pace of the instructor or the class (Broadbent and Kinney).

An instructor-centered learning environment is one of the most widely used teaching methods in the in-class setting where the instructor teaches the theoretical component of the course and explains the materials to the students directly within the limited class hours. Also, the practicum component is carried through the hands-on laboratory setting. The interaction in this setting is direct and active. Typically, homework assignments, quizzes, exams, and laboratory reports are used to assess student learning in theoretical and practical components. Online setting however is in a student-centered learning environment where students learn the prearranged course materials at their own pace. The main challenge in this setting is the lack of direct instructor-student interaction and the requirement of independent and self-motivated students. It requires a collaborative effort between the instructor, the student, and the class (Broadbent, Hall and Oprea).

Successful interactions in an online setting can be achieved by implementing a variety of learning activities such as: group problem solving, discussion boards, simulations, case studies, group projects, and brainstorming sessions (Considine). These components serve as a great addition to the online courses. However, certain course-specific challenges tied to the online course-settings still needs to be addressed by the course instructor. Especially for science, engineering and technology courses where the courses have a practicum component in addition to the theoretical component, or the course topic requires undivided student attention or certain level of mastery in mathematics and science. These challenges have been addressed in many different ways. In an effort to overcome the challenge of offering practicum components in online courses, virtual laboratories, simulation-based laboratories, and remote access laboratories for many courses such as: Fluid Mechanics (Ellis, Jia and

Muste), Thermodynamics (Jeschke, Jovanovic, Forbus), Circuit Design (Yousuf), Mechanisms and Machine Dynamics (Li), Materials Science (Ondracek), and Control Engineering (Overstreet) were developed and implemented by the educators.

Although online education has its own advantages, the effectiveness of student experience in the online environment compared to the in-class environment is questionable. Researchers around the world have been studying the effectiveness of online education (Viswanathan, Gursul, Sung and Silcox). For example, Asarta et al. compared student performance in blended and traditional courses. Their blended courses are the mixture of in-class and online courses. The group used student data from 347 students enrolled in four blended sections and 257 students enrolled in three traditional sections. The group considered student's prior academic achievement in the evaluation. The study demonstrated that a comparison of class-wide performance means between traditional and blended versions of a course may not give an accurate indication of differences or lack thereof. Soffer et al. examined the quality of online academic courses using a multidimensional assessment of students' activities and perceptions. Their work focused on examining students' activities and perceptions in four main aspects: instructional, communication, course workload and overall learning experience in the online course. Their findings indicated that the students were highly satisfied from the online courses and most of them were interested in participating in online courses in the future.

This paper mainly discusses the online Applied Fluid Mechanics and Applied Thermodynamics courses offered in the 4-year Mechanical Engineering Technology program at Farmingdale State College. The development of the online courses was discussed in the previous work (Altuger-Genc and Hung). The authors are proposing an assessment plan to measure the effectiveness of these two online courses. This paper provides a detailed discussion of the development of the assessment plan for the two online courses. The plan will help the authors to identify the strengths and the weakness of the courses in the near future. Unlike general education courses, the student populations of these two courses are relatively low. It will take the authors few semesters to collect meaningful student data in both online and in-class settings. Therefore, it is necessary to plan for the assessment model properly.

2. Design and Development of Online Thermo-Fluid Science Courses

Applied Fluid Mechanics (MET 212) and Applied Thermodynamics (MET 314) are core courses offered in the Mechanical Engineering Technology Department at Farmingdale State College. Both courses are required for the Mechanical Engineering Technology B.S, and Facility Management Technology B.S. Programs. Applied Fluid Mechanics requires Calculus I with applications as a prerequisite course and College Physics II as a co-requisite course. Applied Thermodynamics requires Calculus I with applications and College Physics II as prerequisite courses. Since the courses are designed for engineering technology students, the co-requisite and prerequisite for them is the algebra based physics course and the use of calculus in these courses is minimal. Both courses are offered alternatively between in-class and online settings every semester throughout the academic year. The authors Dr. Gonca Altuger-Genc and Dr. Jeff Hung are the instructors for the Applied Fluid Mechanics and Applied Thermodynamics courses, respectively. They have taught their own course in an in-class setting for at least one semester before developing their online courses. This is to ensure that they have the experience of teaching the courses as well as the understanding of the level of their students.

The online Applied Fluid Mechanics and Applied Thermodynamics courses were the first online engineering technology courses offered by the MET department. They were developed and delivered through Blackboard, a web based course management system. Both courses use standard textbooks that are commercially available on the market. The two online courses have similar course structure to provide students with similar learning environment. The courses are module-based where the teaching materials for each chapter such as lecture notes, examples, assignments, interactive activities, and visual demonstration are grouped into a module. It is important to note that the development of courses did not limit the academic freedom of the authors in the methodologies and tools they employ when they are teaching online. For consistency, the course objective, student outcomes, and course contents remain the same whether students take the course in an in-class or online setting. The authors have developed many course assessment activities such as reading assignments, homework assignments, discussion boards, and exams in the online courses to monitor the continuity of the learning process.

3. Development of Assessment Plan

An assessment plan is proposed in this work to measure the effectiveness of the online Applied Fluid Mechanics and Applied Thermodynamics courses. The methods of data collection and measurement will be applied to both courses for consistent evaluations. The proposed assessment plan serves two purposes. First, it will measure the effectiveness of the online courses. Second, it will provide statistical data indicating the strengths and weaknesses of the online courses.

The effectiveness of the online courses will be measured using student data collected directly from the assignments, quizzes, and exams. The authors will assign similar questions in assignments and exams to students in both in-class and online settings. They will use the data from traditional in-class courses as the benchmark and compare the class means between student groups in both settings to evaluate the effectiveness of the online courses. Although class data will be collected from different student groups throughout the semesters, the continuous data collection and comparison between semesters will minimize bias data in the result. It is important to note that the authors are not evaluating the courses simply based on the comparison of means of course grades. The authors intend to perform a thorough evaluation and measure the effectiveness of the online courses based on each topic of the course materials.

The advantage of individual assignment mean comparison is that the result will indicate the strengths and weaknesses of the in-class and online courses based on the topics of the course materials. This will allow the authors to determine which topics of the course students need more attentions and improve the courses in both settings continuously. The goal of the assessment is to have comparable class means in all topics of the course materials between in-class and online settings. If the plan is proven to be successful, it will be proposed to the department for all online course evaluations.

3.1. Applied Fluid Mechanics Course

The Applied Fluid Mechanics course teaches the fundamental concepts of fluid mechanics and covers the nature of fluids, forces due to static fluids, buoyancy, Bernoulli's Equations, Reynolds Number, Laminar flow and Turbulent flow, drag and lift, and flow of air in ducts, blowers and compressors. Applied Fluid Mechanics Seventh Edition by Robert L. Mott and Joseph A. Untener is used as the course textbook. In addition to the textbook, the entire lecture slides and examples that are covered in the classroom are shared with students through the course page on the Blackboard platform.

Throughout the course a total of 13 chapters are covered through 7 modules. Each module covers 2 chapters, with the exception of the last module, that covers one chapter. Although both in-class and online offerings of the course cover the same materials, the methods of student assessment for the two settings are different. Table 1 provides an overview of the assessment methods for in-class and online course settings along with grade weight distribution for each component.

Table 1. A Comparison of the In-Class and Online Settings of the Applied Fluid Mechanics Course

In-class setting		**Online setting**	
Course components	**Assessment**	**Course components**	**Assessment**
10 Homework Assignments	30%	7 Homework Assignments	15%
2 Quizzes	20%	7 Quizzes	15%
1 Mid-Term Exam	20%	7 Class Interaction Activity	10%
1 Final Exam	30%	7 Module Review Questions	10%
		1 Mid-Term Exam	20%
		1 Final Exam	30%
Total	100%	Total	100%

The in-class setting of the course has weekly homework assignments, 2 quizzes and mid-term and final exams. Students get continuous feedback through their homework assignments and quizzes. In addition, in-class discussion regarding the application of the theoretical concepts they learnt in the class is a part of the learning experience. In the online setting of the course, the homework assignments and quizzes are developed on a per module basis, and a total of 7 homework assignments and 7 quizzes are provided. In addition, module review questions and class interaction activities are provided for each question. The activities provided in the in-class and online settings, and their methods of assessment are provided in Table 2.

Table 2. Methods of Assessment and Effectiveness Measurement for Applied Fluid Mechanics Course

Topics Covered	Method of Course Assessment		Method of Effectiveness Measurement
	In-Class setting	Online setting	
1. Nature of Fluid Mechanics and Viscosity of Fluids 2. Pressure Management and Forces Due to Static Fluids 3. Buoyancy, Stability, Flow of Fluids and Bernoulli Equations 4. General Energy Equation and Reynolds Number, Laminar and Turbulent Flow 5. Flow of Measurement and Forces Due to Fluids in Motion 6. Drag and Lift of Fans, Blowers, Compressors, and Flow of Gas 7. Flow of Air in Ducts and Energy Losses in Ducts	• Reading Assignments Chapters 1-8, 15-19 in the textbook • Homework Assignments (10 HW Assignments • Midterm Exam • Final Exam • Final Grade	• Reading Assignments Chapters 1-8, 15-19 in the textbook • Homework Assignments (7 HW Assignments) • Class Interaction Activity 1-7 (One activity per module) • Module Review Questions 1-7 (One Module Review Question per module) • Midterm Exam • Final Exam • Final Grade	Comparison of class means between the in-class and online settings in homework assignments, midterm exam, and final exam.

3.2. Applied Thermodynamics Course

The Applied Thermodynamics course lays the groundwork for the student's future studies in the area of thermal design, encompassing the fields of power, heating, air conditioning, and refrigeration. Topics covered include basics such as the first and second laws of thermodynamics and equations of state for gases and vapors. Building on this foundation, thermodynamic processes and cycles will be introduced, including the Carnot and Vapor Compression refrigeration cycles. Thermal equipment such as boilers, turbines, evaporators, condensers, compressors, and heat exchangers will be analyzed.

The textbook used in this course is Thermodynamics: An Engineering Approach, 8th Edition by Cengel and Boles. The course also requires the use of a third-party web based assignment and assessment platform, “Connect” supported by the publisher, McGraw-Hill. In addition to the textbook, the lecture notes provided by the publisher are revised to include explanations of the derivation of equations as well as simplification of the areas that involve calculus. Table 3 shows the grading policy of the Applied Thermodynamics Course in both in-class and online settings.

Table 3. A Comparison of In-Class and Online Settings of the Applied Thermodynamics Course

In-class setting		Online setting	
Course components	**Assessment**	**Course components**	**Assessment**
9 Reading Assignments	10%	9 Reading Assignments	10%
9 Homework Assignments	40%	9 Homework Assignments	40%
1 Mid-Term Exam	25%	1 Mid-Term Exam	25%
1 Final Exam	25%	1 Final Exam	25%
Total	100%	Total	100%

Nine topics in the applied thermodynamics course are introduced to students. Assignments of each topic are assigned to the students in both in-class and online settings. A mid-term exam and a final exam are also assigned to the students in both settings. It should be noted that the complexity of assignments and exams and the time allowed for the students to complete the assignments and exams in both settings are the same. Table 4 shows the methods of assessment and effectiveness measurement that will be used for the course. The nine assignment means and the two exam means will be used to evaluate the effectiveness of student learning in each topic in the online environment. Therefore, there will be a total of 12 class mean comparisons, which include nine assignment grades, two exam grades, and one course grade.

Table 4. Methods of Assessment and Effectiveness Measurement for Applied Thermodynamics

Topics covered	**Method of course assessment**		**Method of effectiveness measurement**
	In-class setting	**Online setting**	
1. Introduction and Basic Concepts 2. Energy, Energy Transfer, and General Energy Analysis 3. Properties of Pure Substances 4. Energy analysis of closed systems 5. Mass and Energy Analysis of Control Volumes 6. The Second Law of Thermodynamics 7. Entropy 8. Gas Power Cycles 9. Vapor Power Cycles and Refrigeration Cycles	•Reading Assignments 1-9 (one per each topic) •Homework Assignments 1-9 (one per each topic) •Midterm Exam •Final Exam •Final Grade	•Reading Assignments 1-9 (one per each topic) •Homework Assignments 1-9 (one per each topic) •Midterm Exam •Final Exam •Final Grade	Comparison of class means between the in-class and online settings in each assignment and exam.

4. Conclusions and Future Work

This paper provided a brief overview of the in-class and online settings of the Applied Fluid Mechanics and Applied Thermodynamics courses. The effectiveness of online education is assessed based on the student grades obtained from homework assignments, quizzes, and exams. The assessment of homework assignment grades in addition to the exam grades provides a longitudinal analysis of the effectiveness of each topic. Although using only course grades to assess the effectiveness of online courses is not incorrect, it may not necessarily provide an in-depth assessment of each chapter/topic. The homework and exam grades will be collected and assessed for both in-class and online settings over multiple semesters. This will help the instructors to identify the topics, chapters, or modules students may have difficulty in general. The authors will consult with the department Chair for the course assignment in the upcoming semesters such that they can collect enough student data for meaningful results. The authors will also obtain the institutional review board (IRB) approval and publish their result when they have at least three semesters of student data. If the plan is proven to be successful, it will be proposed to the department for all online course evaluations.

References

Altuger-Genc, G., and Hung, J., 2016, "Design and Development of Online Applied Thermo-Fluid Science Courses" *Proceedings of the 2016 ASEE Annual Conference*, New Orleans, LA, June 26-19, 2016

Asarta, C.J., Schmidt, J.R., 2017, "Comparing student performance in blended and traditional courses: Does prior academic achievement matter?", Internet and Higher Education 32 (2017) 29–38

Broadbent, J. and Poon, W.L. 2015, "Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review", *Internet and Higher Education* 27 (2015) 1–13

Cengel, Y.A. and Boles, M.A. 2014, Thermodynamics: An Engineering Approach, 8th Edition, McGraw Hill Education, 2014

Considine, C.L. , Seek, M.W., and Lester J., 2014, "Strategies for Effective Online Course Development", *Proceedings of the 2014 ASEE Annual Conference*, June 15-18, Indianapolis, IN

Ellis, G. E., Thompson,B.R. and Richards, R.F 2015, "A Remote Access Laboratory for Fluids Education in Mechanical Engineering", *Proceedings of the 2015 ASEE Annual Conference*, June 14-17, 2015, Seattle, WA.

Forbus,K.D., Whalley,P.B., Everett,J.O., Ureel,L., Brokowski,M., Baher J. and Kuehne, S.E. 1999, "CyclePad: An articulate virtual laboratory for engineering thermodynamics, *Artificial Intelligence*, October 1999, Vol. 114, Issues 1- 2, pp: 297-347

Golpek, F. 2012, "Price of higher education and individual demand", *Procedia - Social and Behavioral Sciences* 41 (2012) 349 – 356

Gürsul, F.and Keser, H. 2009, "The effects of online and face to face problem based learning environments in mathematics education on student's academic achievement", *Procedia - Social and Behavioral Sciences* 1 (2009) 2817–2824

Hall, S., Amelink, and Conn, S. 2010, "A Case Study of a Thermodynamics Course: Informing Online Course Design", *Proceedings of the 2010 ASEE Conference*, June 20-23, 2010, Louisville, KY.

Jeschke, S., Thomsen, C. , Richter, T. and Scheel, H. 2007, "On Remote and Virtual Experiments in eLearning in Statistical Mechanics and Thermodynamics", *Proceedings of the Fifth Annual IEEE International*

Conference on Pervasive Computing and Communications Workshops, 19-23 March, 2007, White Plains, NY

Jia, R. Xu, S., Gao, , S. Aziz, E-S. Esche,S. and Chassapis, C., 2006, “A Virtual Laboratory for Fluid Mechanics”, *Proceedings of the 2006 ASEE Annual Conference*, June 18-21, 2006, Chicago, IL

Jovanovic, N.S., 2000, “The Virtual Classroom and Laboratory for Thermodynamics Education”, *Proceedings of the 2000 ASEE Annual Conference*, June 18-21, 2000, St. Louis, MO

Kinney, L. , Liu, M. and Thornton, M. 2012, “Faculty and Student Perceptions of Online Learning in Engineering Education”, *Proceedings of the 2012 ASEE Annual Conference*, June 10-13, 2012, San Antonio, TX.

Li,Y., Esche,S., and Chassapis,C., 2007, “An Architecture for Real-Time Remote Laboratories”, *Proceedings of the 2007 ASEE Annual Conference*, June 24-27, 2007, Honolulu, Hawaii

Muste, M. , Kruger, A., Eichinger, W., Wilson,M., and Xing,T., 2004, “Interactive Remote-Controlled Experiment for Instruction in Fluid

Mott, R. L. and Untener, J.A. , 2014, Applied Fluid Mechanics Seventh Edition, Prentice Hall, 2014

Nissenson, P.M. and Shih, A.C. 2015, “MOOC on a budget: Development and implementation of a low-cost MOOC at a state university”, *Proceedings of the 2015 ASEE Annual Conference*, June 14-17, 2015, Seattle, WA.

Ondracek, R.P. 1999, “Multimedia Virtual Laboratories for Introductory Materials Science Courses”, *Proceedings of the 1999 ASEE Annual Conference*, June, 1999, Charlotte, NC

Oprea, C.L. 2014, “The Internet - a tool for interactive learning”, *Procedia - Social and Behavioral Sciences* 142 (2014) 786 – 792

Overstreet, J.W. 1999, “An Internet-based real-time control engineering laboratory”, *IEEE, Control Systems*, Volume 19, Issue 5, pp:19-34

Silcox,G.D. 2004, “Comparison of Students' Performance in Online and Conventional Sections of Engineering Thermodynamics”, *Proceedings of the 2004 ASEE Annual Conference*, June 20-23, Salt Lake City, Utah

Soffer, T., Kahan, T., and Livne,E., 2016, “E-assessment of online academic courses via students' activities and perceptions”, Studies in Educational Evaluation (2016), In Press

Sung, F. and Mayer, R.E. 2012, “Five facets of social presence in online distance education”, *Computers in Human Behavior* 28 (2012) 1738–1747

Viswanathan, S. and Wyne, M.F 2013, “Looking into Future: Online Engineering Education”, *Proceedings of the 2013 ASEE Annual Conference*, June 23-26, 2013, Atlanta, GA

Yilmaz, O. 2012, “The Effects of “Live Online Course” on Students’ Achievement at Distance Education”, *Procedia - Social and Behavioral Sciences* 55 (2012) 347 – 354

Mechanics”, *Proceedings of the 2004 ASEE Annual Conference*, June 2004, Salt Lake City, UT

Yousuf, A., Wong, A., and Edens, D., 2013, “Remote Circuit Design Labs with Analog Discovery”, *Proceedings of the ASEE Annual Conference*, June 23-26, 2013, Atlanta, GA

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