



A Course Improvement Strategy That Works: The Improvement of Student Satisfaction Scores in a Lecture and Laboratory Course Using a Structured Course Modification Methodology

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Abstract

Courses that have been stable for a long time may, after analysis, be found to struggle to meet current assessment and certification requirements. Over time these courses become not only misaligned, but also need to be refreshed with innovations in industry and teaching techniques. As the course struggles, students may become complacent and disenfranchised as well. This paper examines the potential for this effect in an engineering technology program. This specific course is focused on the accessory systems for aircraft engines such as: carburetors, fuel injection systems, magnetos, and propellers. The course consists of lecture and laboratory sections where the lab section of the course uses actual aircraft components as lab equipment for student use. For clarification, these are functional aircraft components manufactured by aircraft equipment suppliers. However, they are non-airworthy and are not for future installation on airworthy aircraft.

This study evaluates the perceptions of students' experiences in the course using course evaluation surveys before and after three primary changes made to the course: 1) improving the underlying structure and alignment in the course sections through the focus on Federal curriculum requirements for powerplant certification, and ABET-ETAC outcomes, 2) increasing productive and clear applicability to course outcomes in student time on equipment in the laboratory, and 3) increase student feedback opportunities. Implementation of the changes to the course have been made by following a structured methodology.

There has been an improvement in the students' perceptions of the course. After incorporation of the course modifications that have been identified by following the methodology, student satisfaction evaluation scores doubled.

Introduction

In established courses in long-running programs, courses may be stable for a long time, which can produce consistency, but also may lead to staleness of the educational delivery. Community colleges are often more prescriptive where the outcomes and lesson plans are supplied to the instructor by the administration. At a typical four-year university there is a greater level of academic freedom to innovate courses and bring in new material. This can lead to content drift. There are, however, collegiate programs that have regulatory constraints. This article seeks to document a process to reassess the course with respect to the required goals, in a collegiate environment, that has highly structured regulatory constraints.

A misalignment of actual activities versus the course's stated goals and objectives may occur given other changes in program curricula directives or industry needs. In some cases, this situation may arise from excessive instructor workload, documentation requirements, and unclear requirements due to inconsistencies among program evaluators [1]. The result is insufficient maintenance of the content and delivery of the course. All of this notwithstanding, courses need to be reviewed and improved from time to time to remain aligned with changing curriculum or to meet program requirements. Over time these courses may become misaligned and need to be realigned with its required goals. In these courses, students may become complacent and disenfranchised as well.

The course under study is focused on aircraft engine accessory systems such as: carburetors, fuel injection systems, magnetos, and propellers. The course consists of lecture and laboratory sections where the lab section of the course uses actual aircraft components as lab equipment for student use. For clarification, these are functional aircraft components manufactured by aircraft equipment suppliers. However, they are non-airworthy and are not for future installation on airworthy aircraft. The course is part of both a Federal certificated aviation program and of an ABET-ETAC accredited program for aeronautical engineering technology.

While the course continued to meet the certification requirements of both Federal and ABET-ETAC, the instructor believed that there was some misalignment beginning to occur. In the fall of 2016, student evaluation survey provided data that revealed concerns about: 1) the combination of two courses having been combined into one course and the expansion of the course content, 2) the sufficiency of the number of tools, test equipment, and manuals, and 3) a general feeling of course disorganization. Being committed to continuous improvement and student learning, the instructor set upon a path to dramatically alter the course. Modifications were implemented over the following two semesters: spring and fall 2017.

This study evaluated the effectivity of following a structured methodology process of improving the perceptions of students' satisfaction in the course. Course evaluation surveys from the fall 2016, taken before modifications were made, and those surveys from the spring 2017, taken after modifications, were compared to measure the effectivity of the methodology. The three primary areas of focused attention were: 1) improving the underlying structure and alignment in the course lecture and laboratory sections through the focus on Federal mandated curriculum requirements for powerplant certification as a part of a large aviation program, and ABET-ETAC outcomes; 2) increasing productive and clear applicability to course outcomes in student time on equipment in the laboratory; and 3) increase student feedback opportunities. By making changes to the course lecture and lab sections there was a significant improvement in the students' perceptions of the course.

Powerplant Systems Course

This 300-level course was an aircraft powerplant system lecture and laboratory course containing theory, applications, and hands-on projects. This course was part of a Federal Aviation Administration (FAA) Title 14 CFR Part 147 certificated program, leading to the students being qualified to test for the Airframe & Powerplant certificate. In the fall of 2016, the course had the following published objectives from the Federal Aviation Administration:

- 1) “Students will develop the knowledge and skills required to evaluate the condition of and support airworthy operation of the aircraft fuel metering, ignition, propeller, and propeller control systems components under study.
- 2) Students will understand and be able to apply knowledge of aviation fuels to operation of the engine and the powerplant components under study.
- 3) Students will be able to identify and analyze factors that potentially impact on the cost and appropriate use of aviation fuels.”

The course also had the following ABET-ETAC requirements:

- 1) This course was part of the ABET-ETAC accredited aeronautical engineering technology program and provides evidence for student outcomes related to criterion 3, parts b. and j. The program accreditation committee within the department used these definitions:
 - a. “Outcome b. is an ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies.
 - b. Outcome j. is a knowledge of the impact of engineering technology solutions in a societal and global context [2].”

Course objectives were met by partially by the completion of 21 laboratory projects:

- 1) Engine stand identification and conformity
- 2) Magneto overhaul
- 3) Comparative life costs for magnetos
- 4) Starting vibrator and fault diagnosis exercise
- 5) Fuel volatility
- 6) Alcohol in fuel
- 7) Fuel pumps
- 8) Carburetor overhaul
- 9) Bendix fuel injection
- 10) Fuel control - Allison 250 (turbine)
- 11) Aircraft/engine/propeller combinations
- 12) Blade angle measurement, AOA, pitch calculation and propeller track
- 13) Propeller rotational forces
- 14) Propeller removal and installation
- 15) Propeller nick inspection and repair
- 16) Propeller minimum width and thickness
- 17) Propeller de-ice lab

- 18) Propeller dynamic balance
- 19) Negative torque sensing and auto-feather
- 20) Propeller and composite propeller inspection
- 21) Aircraft 100 HR inspection

Prior to the spring of 2016, this single course was two separate courses: 1) ignition and fuel systems, and 2) propeller systems. The 21 laboratory projects were generally equally divided between the two courses. A new instructor was assigned to the course in spring 2016. The course was largely unchanged in terms of content and order of topics during this first semester of teaching.

Methodology

To improve both student and instructor satisfaction, the instructor consulted more experienced faculty and subsequently was asked to review and analyze the course for compliance to FAA requirements, and ABET-ETAC outcomes. The instructor reviewed both lab and lecture materials to ensure that the necessary elements were covered, and then the course was streamlined to allow adequate time on necessary elements. In addition, the course was analyzed to reduce or eliminate extraneous elements that had crept in over the years to the two individual courses, but had not been pruned appropriately during the merge of the two courses into one.

This paper discusses modifications made to both lecture and laboratory section, but the focus is on the improvements made to the laboratory section. The methodology steps (shown in figure 1) for the course improvement are:

- a) Conduct course post mortem through the review of the course evaluations and instructor self-reflection. Identify specific areas of focus that are actionable, realistic, and include potentially impactful changes.
- b) Review the current lecture topics and laboratory projects and identify those that are required by current FAA certification and ABET-ETAC requirements. Analyze the remaining lecture topics and lab section projects to determine if any could be eliminated, combined, or moved.
- c) Review equipment availability, state of repair, and space required. Order equipment and spares. Evaluate space needs and request changes or develop alternate plans.
- d) Align the timing and content of the lectures to better match the progress expected in the lab section.
- e) Prioritize and implement identified changes from the current semester or previously identified future changes. Document any changes that cannot be implemented immediately for possible future implementation.
- f) Conduct the revised course.

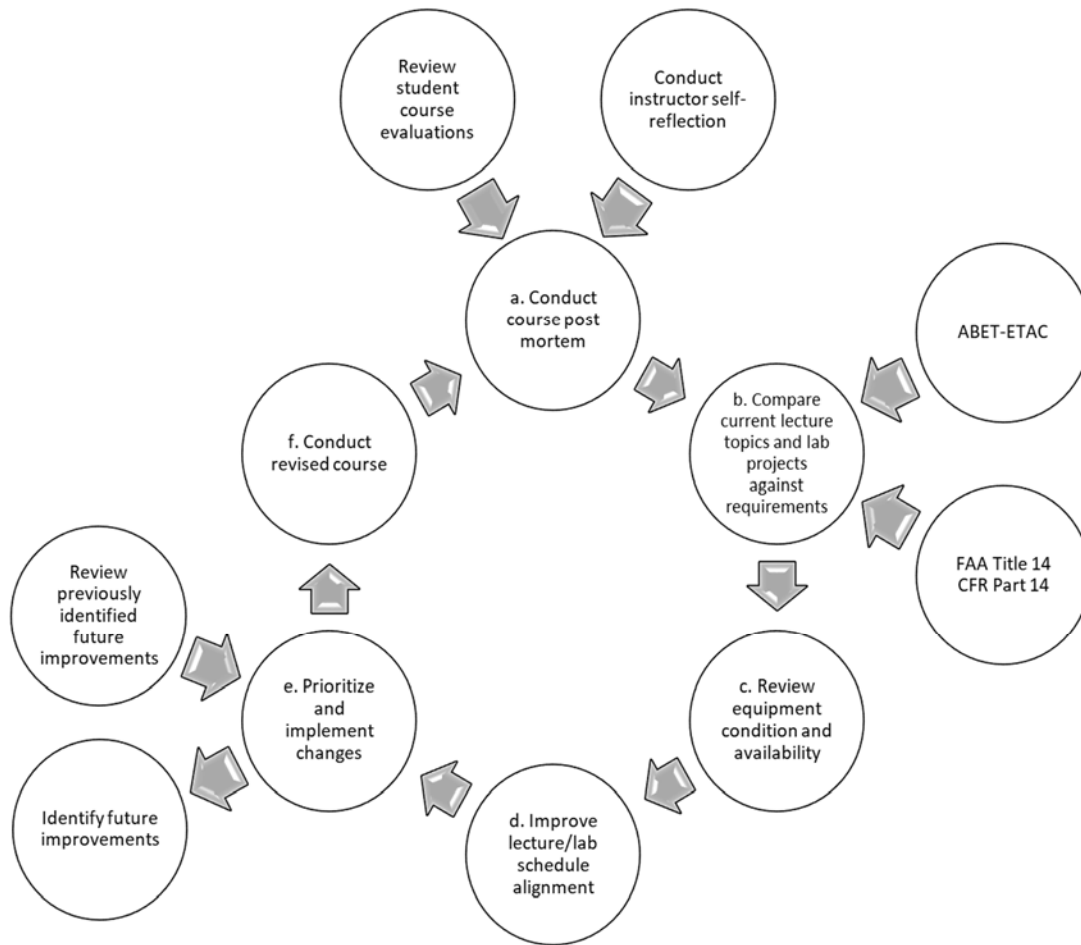


Figure 1 - Course modification methodology.

Assumptions

In the spring 2016, the instructor was new to the course and new to teaching. This level of experience may have contributed to the low student satisfaction scores for that semester. For this study, the assumption is that the experience level of the instructor does not impact the scores.

Results

This section discusses the results for each step in the methodology.

a. Conduct post mortem. Spring 2016 student course evaluations could by no measure be considered stellar. Some students were clearly unhappy with the course. There were a couple of overarching reasons expressed by the students. First, they felt that the equipment in the laboratory areas was inadequate. Second, the students felt that the lecture material seemed disorganized and diluted. After a time of self-reflection, the instructor consulted more experienced faculty members for advice on how to begin improving the course. Improvements were focused on four major areas: 1) increasing the clear applicability to course outcomes during student time on equipment in the laboratory, 2) obtain laboratory equipment, materials, and

documentation to complete laboratory project, 3) improve organization and focus by improving the underlying structure and alignment in the course sections through the focus on the Federal mandated curriculum requirements and the ABET-ETAC outcomes, and 4) increase student feedback opportunities.

b. Compare current topics and projects to requirements. To improve the structure of the course, topics were aligned with the current Federal standard certification requirements. Of the previously listed 21 laboratory projects, only eight of them aligned with current requirements and are indicated with an asterisk (*):

1. Engine stand identification and conformity
2. * Magneto overhaul
3. Comparative life costs for magnetos
4. Starting vibrator and fault diagnosis exercise
5. Fuel volatility
6. Alcohol in fuel
7. Fuel pumps
8. * Carburetor overhaul
9. * Bendix fuel injection
10. Fuel control - Allison 250 (turbine)
11. Aircraft/engine/propeller combinations
12. * Blade angle measurement, AOA, pitch calculation and propeller track
13. Propeller rotational forces
14. * Propeller removal and installation
15. * Propeller nick inspection and repair
16. Propeller minimum width and thickness
17. * Propeller de-ice lab
18. * Propeller dynamic balance
19. Negative torque sensing and auto-feather
20. Propeller and composite propeller inspection
21. Aircraft 100 HR inspection

The results of this analysis indicated to the instructor that a substantial restructuring of the laboratory projects was needed. For instance, aviation fuel projects, which were never FAA or ABET-ETAC requirements, were removed to allow for more time for other required projects. Complete restructuring or project removal was not required in all cases. In other cases only minimal changes, such as adding more topical complexity, were required to align again with current FAA or ABET-ETAC requirements. Once completed, the new list of projects more aligned with FAA requirements was developed.

Those course projects that aligned directly with a FAA requirements are indicated below with an asterisk (*) and some projects possibly covered more than one FAA required project; the other projects listed provided necessary prerequisite skills needed to accomplish the directly aligned projects:

1. Magneto identification and description
2. * Magneto overhaul

3. Time a Slick magneto
4. * Fuel system components repair and airworthiness
5. * Float type carburetor component identification and function
6. * Carburetor overhaul
7. * Bendix RSA fuel injection
8. Propeller identification and purpose
9. * Blade pitch calculation
10. * Fixed pitch propeller removal and installation
11. * Constant-speed propeller disassembly, inspection, and reassembly
12. * Propeller inspection and nick repair
13. * Anti-icing and de-icing inspection, check, service, and repair of ice control systems
14. * Dynamic balance
15. * Static balance and blade track
16. * Governor identification and operation
17. Boilermaker Aircraft Repair Service

This change increased the amount of time student spend on activities in the lab section with clear and obvious connection to course outcomes. The previous schedule included only 8 of 21 projects with direct connection to Federal requirements. The new list had 13 of 17 projects with direct connection to FAA requirements.

When the ABET-ETAC outcomes for this course were reviewed, it was found that support for *outcome b., an ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies*, still made sense for the course. The course evidence for outcome b. where students are asked to calculate geometric pitch inches and blade angles for propellers, stayed fundamentally the same. However, *outcome j. knowledge of the impact of engineering technology solutions in a societal and global context*, was determined to be a better fit in another course. After consultation with the program's ABET-ETAC coordinator, that move was planned to take effect in fall 2018.

c. Review equipment availability, state of repair, and space required. In the spring of 2016, the laboratory space was changed to improve student learning by combining two disconnected lab spaces into one. One space was a small room, with a maximum capacity of 12 students, (approximately 9 feet by 20 feet) where the students sat at tables facing the walls. The students sat shoulder to shoulder and had little room to do the project work. This room was originally an office, and had been pressed into service decades before as a small laboratory. When the course was originally set up the student enrollment had been approximately 25% of the 2016 enrollments.

The second space was larger area (approximately 20 feet by 60 feet), and had maximum student capacity of 16. The limit on the student numbers for this larger area was due to the fact the second space was on a mezzanine that had a weight limit imposed on it for personnel occupancy. This space was being used as a combination of student laboratory lab space and storage space for other labs. The clutter from the storage for other projects limited the space available for the student learning in the course being evaluated here. Over three to five months the larger

laboratory space was cleared and cleaned allowing for the consolidation of the two lab spaces into the one larger area. This consolidation allowed for all of the course's activities and equipment to be co-located into one lab space. This provided a better student learning experience.

The larger space is shown in figure 2 and figure 3.



Figure 2 - New laboratory space, mid-change.



Figure 3 - New laboratory space, after changes.

Students frequently commented, both in formal course evaluations and informal conversations, on the lack of enough spare parts, and on broken or missing tooling. While there were sufficient parts and tools to accomplish the course objectives, teaching larger numbers of students with few

parts and tools required constant revision of student project scheduling. The students interpreted the instructor's constant adjustments to lab activities as being disorganization by the instructor.

Over two semesters of course improvement, approximately \$10,000 was spent replenishing spare parts and replacing broken equipment with functioning or new model equipment. Some examples of the equipment purchased were: a simple wrench needed to complete a propeller removal laboratory project, new magneto testing equipment, new magneto timing lights, additional propeller blade protractors, and replacement carburetors. The instructor solicited donations from industrial partners, and found some existing donation programs already in place by industry. Replacement magnetos were donated by Champion Aerospace, Inc. New propeller documentation was donated by Hartzell Propeller, Inc.

While this \$10,000 may seem like a lot of money for many educational programs, this sum is a tiny amount of money needed to support an aviation program. This funding simply represented an infusion of money in one lump, which should have been added incrementally over many previous years. This is not to imply that the previous instructors were negligent or inattentive, but rather shows how without an occasional review of the course, instructors can progressively compensate for diminishing resources. Without realizing it, instructors can find themselves with cobbled together equipment, labs conducted using workaround processes, and truncated activities. The result being a diminishing student learning experience and student satisfaction.

Improvements in technology were also incorporated into the lab space to aid student learning. For instance, a large 40" monitor was installed so that students could receive just-in-time lessons during the lab. The monitor was purchased through a larger laboratory space improvement project led by another professor. A computer was moved to the space and connected to the internet to allow students to find appropriate aviation information from Federal and OEM websites.

d. Align the timing and content of the lectures. A careful comparison of the course lecture sequence and the lab sequence revealed that only a minor modification to the lecture schedule was required. The lecture materials were pruned to more closely follow the lab sequence. The instructor iterated between this step and the previous, and discussed options with faculty mentors.

e. Prioritize and implement changes. After a list of all the desired changes was compiled, the changes were prioritized. Every change could not be implemented all at once due to limitations in resources such as space, financial support, and other commitments. Some changes were implemented at once, others started but were not completed, and further changes were documented on a list of future improvements.

Student feedback concerns were primary in addressing any course improvement activity. Their concerns were: 1) the combination of two courses having been combined into one course, and the expansion of the course content, 2) the sufficiency of the number of tools, test equipment, and manuals, and 3) a general feeling of course disorganization. Step *b. Compare current topics and projects to requirements*, was instrumental in increasing the focus and organization in the course. Also by modifying or removing topics the course would feel to the students more like a singular

class and not two cobbled together courses. To address the status of the laboratory equipment, most of the effort was accomplished in step *c. Review equipment availability, state of repair, and space required*. This was one area where student visibility and interaction was at the highest and the assumption was that small changes could result in large returns. The hope was the greater focus in the course topics and projects, concern 1, and improvements in the laboratory facilities and equipment, concern 2, would improve the feeling of organization in the course.

Changes were accomplished that did not directly relate to stated student concerns, but were intended to improve student engagement and learning. The lecture section of the course included a transition from a pure lecture format to a more interactive format that was more engaging and collaborative for the students of today. Some efforts included incorporating active learning strategies including information and communication technology (ICT) [3] and the use of equipment or objects [4]. The inclusion of ICT included the use of commercially available online quiz creator Kahoot!; a smartphone application and showing more on-line videos with specialized information found on YouTube.com. The instructor brought equipment, or objects, more frequently into the lecture so students could both see and feel the component being discussed. While not a new technique, the technique of passing around equipment and parts during the “lecture” portion of the course still remained an active dimension to course learning and of student engagement.

Newer technologies still need to be included in the course going forward to provide a counterpoint to the fundamental theory and operational material. While the fundamentals of how carburetors and propellers have not changed in fifty years, the perception of many students is the information contained in the course is outdated material.

In discussions with faculty mentors, the inclusion of student feedback mechanisms was highlighted as a relevant and needed addition to the course and vital to student satisfaction. Students had anecdotally been seen to have a desire for greater input and control in the improvement their courses. To facilitate this input, multiple avenues for feedback were incorporated into the course. The first was a formal and anonymous mid-semester course evaluation. This gave the students an opportunity to highlight portions of the course where they saw problems, and still gave the instructor time to adjust prior to the end of the semester.

Less formal, and not anonymous, feedback sheets were included in the students’ lab manuals. These sheets were used to identify specific problems students saw in the laboratory section. These input forms provide specific areas of suggested improvement in the lab projects, and gave the students extra credit points. The use of extra credit points provided incentive for critical thinking, and took advantage of the students’ motivation to do work for extra credit points. This also took advantage of the ability to provide a more rapid input and feedback loop for the students. These input forms in the lab manuals were helpful because they provided specific actionable areas of desired improvement directly from the students. Typical topics provided from students were: additional instruction in a particular area such as: magneto internal timing, reports that equipment that did not work as expected, or additional/improved documentation was required.

After the changes were made, in the spring of 2016, the course removed one of the course objectives relating to the knowledge of fuels, their cost, and appropriate use of aviation fuels. The remaining fuel related outcome that focused on the operation of components was kept. The new Federal objectives were:

- 1) “Students will develop the knowledge and skills required to evaluate the condition of and support airworthy operation of the aircraft fuel metering, ignition, propeller, and propeller control systems components under study.
- 2) Students will understand and be able to apply knowledge of aviation fuels to operation of the engine and the powerplant components under study.”

f. Conduct the revised course. In spring 2017 and fall 2017, the instructor conducted the modified course.

Discussion and Reflection

After all the changes, the course was improved. By following the course modification methodology, the course was changed in the major areas of student concern: 1) combination of the courses and the expansion of the course content, 2) missing tools and manuals, and 3) a general feeling of course disorganization. Through the process of aligning the course laboratory projects with FAA and ABET requirements, some projects were removed due to creep over the years and other projects were only slightly modified. This gave the students time to be complete the remaining projects without feeling rushed or working on projects that do not matter. A year long, and still ongoing, effort to obtain or purchase equipment, spares, documentation, and tooling made tangible improvements to the laboratory section. The addition of feedback avenues gave the students a voice in the areas in the course they felt needed attention, and provided the instructor areas for future improvement.

The question was, did it make a difference in terms of student evaluations? In the spring of 2016, student evaluation scores were lower than what the instructor considered acceptable. In the two main questions of overall quality of the course and overall quality of the instructor, the students rated the course a 2.0 and the instructor a 1.9. The scale was zero to five, where five was highly satisfied. By fall of 2017, scores raised markedly. Overall instructor score went from 1.9 to 3.8. Overall course score went from 2.0 to 3.8. The course evaluation scores nearly doubled for the two primary questions related to satisfaction with the overall course and the instructor.

After careful review and reflection, a list of obtainable actions was created to improve the course and student experience: 1) increasing the clear applicability to course outcomes during student time on equipment in the laboratory, 2) obtain laboratory equipment, materials, and documentation to complete laboratory project, 3) improve organization and focus by improving the underlying structure and alignment in the course sections through the focus on the Federal mandated curriculum requirements and the ABET-ETAC outcomes, and 4) increase student feedback opportunities.

Upon reflection, the instructor noted the difference in the student expectations between when the instructor was an undergraduate student twenty years earlier, and students of today. The

instructor came to the course with the mindset that the students would accept the course and the activities given. Very quickly the instructor recognized that the students in the course had a strong desire to provide input to the course activities, and interact more with the instructor on course improvement. This recognition allowed the instructor to rapidly implement the various feedback mechanisms and act on the feedback.

The course improvements this far have resulted in an almost 100% increase in satisfaction scores in the student population from fall 2016 to fall 2017. The methodology may seem simple, but execution can be difficult. This is not a one-shot effort. Every semester requirements must be reviewed, student evaluations must be considered, and lecture and laboratory material must be evaluated. Anecdotally, the instructor is also more satisfied with the course and is excited about future improvements.

Future Work

With all the effort that going into improving the course, there is still much left to be done. Improvements to lab equipment is an ongoing effort. Lab projects can always be modified to provide a better student learning experience through the inclusion of better reference materials, equipment to perform additional tasks on the components, including more testing and troubleshooting activities.

Engaging students for three hours a week of lecture can be a challenge. In the future, development and implementation of more active learning activities, such as problem-solving activities and group work, need to be added to the course.

The work that needs to be done is:

- Continue to gather data from students.
- Many things were changed at once. The researcher needs to isolate root causes of the improvement.
- Improve and institutionalize the methodology, in order to allow for academic freedom consistent at a four-year research based institution.
- Engage with researchers in course design to develop synergies with long established and emerging models.

Conclusion

Student perceptions are reflected in course evaluations and are important to the success of instructors and courses. Even after two semesters of improvement, this course faces many challenges. Experience is the best teacher for a novice instructor, and the instructor benefited from the combined experience of other instructors in the department. The tangible actions resulted in measurable student satisfaction improvement scores.

Finding oneself in a situation where a course requires restructuring means that the instructor should take defined steps to improve the course. In all ways that matter, going back to the basics of course design is important. What are the required outcomes? What are the different requirements? What facilities and equipment are needed?

In addition, gaining input from the students is invaluable for finding the pressure points perceived by students. Those pressure points may not match the pressure points of the instructor. Self-reflection and solicitation of advice from more experienced faculty may help the instructor prioritize improvement actions. By focusing on those areas where student and instructor priorities match: student satisfaction and engagement increase.

In a post “Great Recession” economy there are indications that more programs at four-year institutions are expected to contain defined practitioner-based skills and objectives. If we expect this to be the case, then developing a methodology for ensuring compliance with practitioner-based objectives and higher learning needs becomes important to provide the graduates with practical skill sets and maximize their career opportunities.

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