The Role of Timely Actionable Student Feedback in Improving Instruction and Student Learning in Engineering Courses

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Abstract

Traditional course instruction has students on the receiving end, giving them limited opportunity to contribute to their learning environment, and improve their learning experiences. The most common, and often only, form of course-level student feedback typically used in most universities is an end-of-semester survey, which has no influence on the current course, and provides a slow path to improvement. This study presents a student-centered assessment model that provides timely actionable feedback allowing optimization of course instruction during the semester with the objective of maximizing student learning and the overall student satisfaction. The proposed model uses a simple structured approach that incorporates questions requiring numerical scores and open-ended questions to solicit student feedback.

This model includes four surveys administered over the semester. The first survey is given on the first week of classes to familiarize the instructor with the background and career goals of each student and their course expectations. Based on the findings of this survey, the instructor can adjust or clarify aspects of the learning objectives, help students strategize their studying based on their individual background, and plan, early on, a "fine tuning" of the course schedule to add needed or remove obsolete material. The second and third surveys are anonymous and give the students the opportunity to assess various aspects of the course and their learning experiences. Each survey is separated into three sections. The *Course section* focuses on assessing the course structure, including the course organization, teaching tools, instructor's lecture notes, textbooks, and homework. The *Instructor section* focuses on assessing the instructor's overall support of the course, including their teaching skills, responsiveness to questions, learning environment, and academic concern. The *TA section* includes an overall rating for the teaching assistant (TA). At the end of each section, a "Comments/Suggestions" box is included, where the students are encouraged to write their comments. These surveys are administered typically at 1/3 (Week 5) and 2/3 (Week 10) of the semester.

Based on the findings of each survey, the instructor makes a brief presentation during class, where the most frequent comments/issues are discussed along with actions to address them. The third survey further serves as a measure of the efficiency of the adopted actions from the second survey. The fourth survey is administered by the university typically during Week 14 of the semester and serves as a final assessment provided by an independent entity. This assessment model has been applied by the authors in two universities for the undergraduate courses of Statics, Engineering Mechanics: Dynamics, Structural Concrete Design and Computer Applications in Engineering and Construction, and the graduate courses of Advanced Mechanics of Materials, Structural Dynamics and Engineering Risk Analysis. The findings of this study show that timely actionable feedback is essential in improving student learning and satisfaction within the semester, and helps increasing engagement and excitement for a course, because the students realize that their opinion matters and can shape the structure of a course to their benefit. Statistical analyses of the surveys are presented and the sample surveys are provided as an assessment tool to potentially be adopted by other educators in engineering courses.

1 Introduction

Traditional course instruction has students on the receiving end, giving them limited opportunity to contribute to their learning environment, and improve their learning experiences. In traditional course instruction, the instructor decides all aspects of the course to its very fine details, which he/she implements during the semester. Student feedback, the value of which has been identified from several studies [1-4], is limited within this process, most commonly taking the form of an end-of-semester survey, which is often mandated by State laws and, practically, has no influence on the learning experience of the students currently attending the course. Considering that, in most universities, the same course is given once a year and not always by the same instructor, improvements to the course structure and delivery as well as the learning environment are extremely slow; in the order of several years. The inefficiency of this approach is particularly consequential to the students, who are not given the opportunity to communicate their concerns in a timely manner, and, as a result, are exposed to learning environments that fail to engage them into the learning process, significantly hindering their learning of the course material [1-7]. The inefficiency of this approach is also consequential to junior faculty, who are required to improve their course instruction over short periods of time, usually 4 to 6 years, often with limited mentorship, usually via in-class evaluations conducted *once* a year by senior colleagues, and more recently, through additional university-level workshops.

2 Scope

The objective of this paper is to present a *student-centered assessment model* that provides timely actionable feedback allowing optimization of course instruction during the semester with the goal of maximizing student learning and the overall student satisfaction. The proposed model incorporates a simple structured approach that include questions requiring numerical scores and open-ended questions to solicit student feedback, mechanisms to assess, address and implement that feedback, and methods to validate the success of the implemented improvements.

The proposed model has been implemented in two universities (University of Colorado Boulder and Texas A&M University) and has been utilized by two faculty, i.e. the two authors. Implementation of this course model resulted in an increase of the students' rating within the semester and has led to long-term improvements in the instruction and overall organization of those courses.

Unlike conventional formative models [8, 9] that focus on quantifying student learning through muddiest point papers or quizzes (and other methods [8, 9]) and provide feedback to the students, this assessment model focuses on the student satisfaction for the entire course structure and delivery as well as the perceived learning of the material by the students based on feedback solicited by the students. By focusing on the student satisfaction and perceived learning of the material, the proposed model is complementary to, and should be used together with, summative assessment tools (e.g. HW assignments, quizzes, midterm exams, final exam), which explicitly focus on quantifying actual student learning in an absolute sense. This complementarity also rests on the fact that the performance of students in HW assignments and midterm/final exams is clearly associated with their overall satisfaction about the course structure and delivery [10, 11].

3 Description of the Proposed Assessment Model

This model includes four online (3 via Google Forms and 1 via the University online survey system) surveys administered over the semester. The ***first survey*** –termed ***Student Info Questionnaire*** – is given on the first week of classes and is intended to familiarize the instructor with the background and career goals of each student as well as their learning expectations from this course. Prior to administering this survey, the instructor should clarify the learning objectives and the entire structure of the course. This survey should not be administered prior to a complete presentation of the course syllabus. After this survey has been administered and the instructor has reviewed the student responses, he/she can adjust or clarify aspects of the learning objectives in class, and plan, early on, a "fine tuning" of the course schedule to add needed or remove obsolete material based on strengths and weaknesses on the students' technical background. It is often the case that students have expectations that do not align well with the learning objectives of a course, or may not have acquired sufficient technical competence in certain prior courses. Furthermore, the instructor can help individual students, upon their request, to strategize their studying based on their individual background and fill in such gaps.

A sample of a recently administered Student Info Questionnaire is shown in Figure 1. Although different instructors can select a different list of questions, some questions that are highly recommended are: (i) "list of prior relevant courses", not just the prerequisites, because they help the instructor identify gaps in the knowledge of fundamentals, (ii) the description of "expectations" for the course, and (iii) "anything else you would like [the instructor] to know", which provides a formal, yet discrete, venue for students to communicate potential difficulties and concerns. A set of other questions, such as those on hobbies and prior work experience, allow the instructor to get to know the students better and help establishing interpersonal rapport with them early on during the semester. Establishing interpersonal rapport often helps maintaining a good learning environment [12].

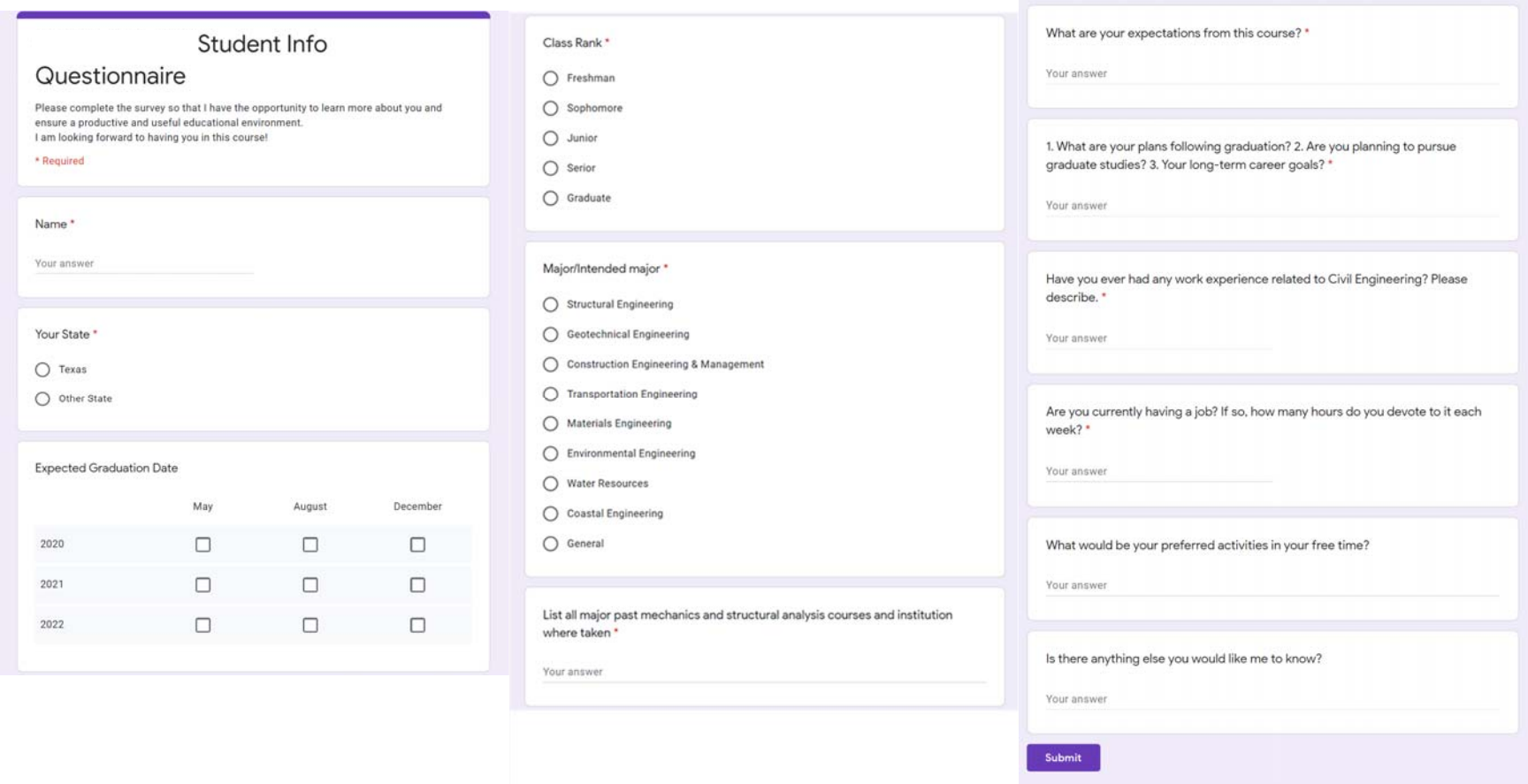

Figure 1. Example of Student Info Questionnaire

The ***second*** and ***third online*** (via Google Forms) ***survey*** – termed ***1st and 2nd Course Evaluation Survey*** – is anonymous and give the students the opportunity to assess various aspects of the course and their learning experiences. Each course evaluation survey is separated into three sections: the course section, the instructor section and the teaching assistant (TA) section. The *Course section* focuses on assessing the course structure, including the course organization, teaching tools, instructor's lecture notes, textbooks, and homework, the latter of which may appear as a separate subsection. The *Instructor section* focuses on assessing the instructor's overall support of the course, including their teaching skills, responsiveness to questions, learning environment, and academic concern. The *TA section* includes an overall rating for the TA, while more questions could be added based on the TA's involvement in the course. At the end of each section, a "Comments/Suggestions" box is included, where the students are encouraged to provide comments and suggestions about improving the course. Furthermore, the *Course* and the *Instructor sections* are completed with an "overall" course and instructor ratings, which represent the overall positive or negative perception of the students. These course evaluation surveys are administered typically at 1/3 (Week 5) and 2/3 (Week 10) of the semester. Prior to administering these surveys, it is important that the instructor briefly discusses their objectives during the class and emphasizes the fact that these surveys give voice to the students' concerns allowing for improvements in a timely manner and that the student input matters to the instructor. *The authors usually administer these surveys, just days before midterm exams, thus, giving the students the opportunity to evaluate the class at the same time/period, when the instructor will evaluate their own learning. The authors' intention with this timing is to create a sense of fairness amongst the students, because both the instructor and the students are evaluated and evaluate, and rally them in supporting this entire evaluation model – yet, further research is needed to explore how giving the survey at other times may affect the students sense of fairness about the course delivery*. After processing of the student responses, the instructor should present the findings in the next class, identifying the comments/concerns/issues mentioned by most students, and put forward actions that he/she will be taking to address them within the current semester.

While the 1st course evaluation survey (2nd survey of the model) primarily intends to identify concerns, i.e. areas for improvement, the 2nd course evaluation survey (3rd survey of the model) has a two-fold goal, namely, (i) assessing the efficiency of the adopted actions determined based on the findings of the 1st course evaluation survey, and (ii) identifying new areas of improvement.

A sample of a recently administered Course Evaluation Survey is shown Figure 2. The survey includes more than 20 questions, evenly balanced between the *Course* and *Instructor sections*. The course section includes questions that assess course structure, class organization and preparation, course intellectual challenge, HW quality and grading fairness, overall learning, effectiveness of electronic media to support learning, and the usefulness of posted notes, and overall rating of the course. The instructor section includes questions that assess their presentation and explanation skills, their enthusiasm about the material, their effectiveness in encouraging interest for the material, their responsiveness to student questions, the overall class learning environment, their availability for assistance, and their concern about the students learning the material. Both sections end with a question on assessing the overall rating of the course and the instructor, respectively, as well as a "Comments/Suggestions" box for open ended

recommendations. These questions (together with the TA evaluation section) provide a holistic review of all major aspects of a course, allowing the instructor to obtain broad and detailed student feedback to support future changes in the course delivery.

The rating scale used in the questions of the course evaluation surveys is selected to match the scale of the rating system of each university. Thus, course evaluation surveys administered in University A use a 6-point scale (A to F), whereas, course evaluation surveys administered in University B use a 5-point scale (A to E). “University A” refers to the Department of Civil, Environmental and Architectural Engineering at the University of Colorado Boulder, while “University B” refers to the Zachry Department of Civil and Environmental Engineering at Texas A&M University. Also, for the discussions to follow, “Instructor 1” refers to the first author and “Instructor 2” refers to the second author.

1st Course

Evaluation

GENERAL RATING: A: Very good to E: poor

Note: The system does not keep your name. Please make sure that you do not use your name in any of the fields.

* Required

COURSE: Rate organization of course content (syllabus, posted notes, eCampus, HW organization) *

Choose

COURSE: Rate class preparation and organization: Are the class activities well-prepared and organized? *

Choose

COURSE: Rate the intellectual challenge of the course *

Choose

HW: Rate quality of assigned HW: Does the assigned HW help you better understand the course material and achieve the course objectives? *

Choose

HW: Rate fairness in HW grading: Is the HW graded fairly and in accordance with the HW rules? *

Choose

COURSE: Time you spend for the course (including classes) in hours/week *

Choose

COURSE: What percentage of the class have you attended? *

Choose

COURSE: What percentage of the office hours have you attended? *

Choose

COURSE: Rate how much you have learnt in this course so far *

Choose

COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning *

Choose

COURSE: Rate usefulness of posted notes *

Choose

COURSE: Overall rating of the course *

Choose

COURSE: Comments/Suggestions on the course: 1. What do you like the most? 2.What do you like the least? 3. Other comments/suggestions? *

Your answer

INSTRUCTOR: Rate instructor's presentation and explanation skills: The instructor clearly explains the material so that I can understand it. *

Choose

INSTRUCTOR: Rate instructor's enthusiasm about the class *

Choose

INSTRUCTOR: Rate instructor's effectiveness in encouraging interest *

Choose

INSTRUCTOR: Rate instructor's responsiveness: The instructor is open to my questions, and effectively answers them. *

Choose

INSTRUCTOR: Rate class learning environment: The instructor maintains a good learning environment for me. *

Choose

INSTRUCTOR: Rate instructor's availability for assistance: The instructor willingly makes time to help other students and me *

Choose

INSTRUCTOR: Rate instructor's academic concern: The instructor seems to care that I learn this material. *

Choose

INSTRUCTOR: Overall rating for the instructor *

Choose

INSTRUCTOR: Comments/Suggestions for the instructor *

Your answer

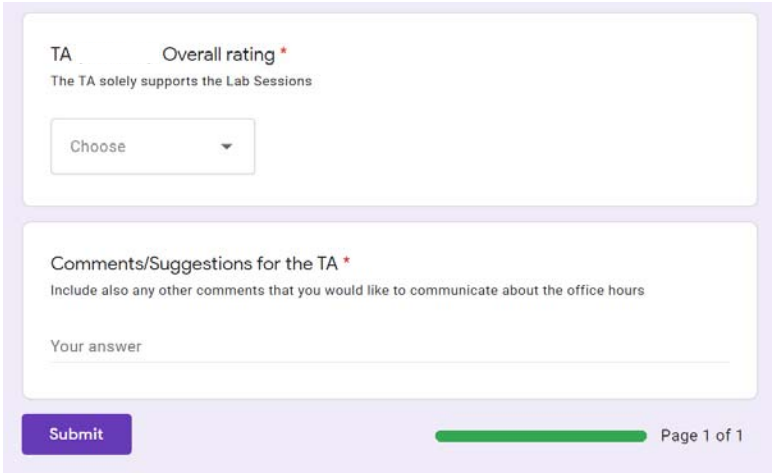

Figure 2. Example of Course Evaluation Survey

The ***fourth survey*** – termed ***3rd Course Evaluation Survey*** – is also anonymous and is administered by the university typically during the last week of classes. This evaluation serves as a final assessment provided by an independent entity. Unfortunately, in most universities, the faculty cannot include their own questions and as a result a comparison of the first two surveys with the final survey is not always possible. However, the student feedback from this final survey (together with the feedback from the previous two course evaluation surveys) can be used to guide refinements in the design of the course, when it is delivered again by the instructor in the future.

4 Implementation of the Proposed Assessment Model

Implementation of the proposed assessment model is easy and straightforward, and requires only minimal time from the instructor. Indeed, it requires some time from the instructor to prepare the very first online student information questionnaire (1st survey of the model) and the very first online course evaluation survey (2nd and 3rd survey of the model). However, once those surveys are prepared once (e.g., in Google Forms), they can be used for several courses and over several years. Also, modifications to these forms to include more/less questions or modify existing questions are easy and can be performed rapidly.

Administering the survey does not require much time from the instructor. The authors, for example, usually administer these surveys by email or course announcement within the course website and give the students 2-3 days to respond.

Processing of the student responses is also straightforward and quick, because Google Forms (and other online platforms) automatically present summaries of the student responses. Thus, calculation of average values and standard deviations of the student ratings requires only minor post-processing by the instructor. Slightly more time demanding is the review of the course and instructor "Comments/Suggestions", which requires grouping of similar comments and quantification of their frequency, i.e. how many students have expressed the same concern. Following this processing, the instructor needs to identify major concerns, which should be addressed. In the authors' experience, concerns that are shared by more than 10-20% of the students of a course should be addressed by the instructor. The extent to which these comments are addressed depends on their frequency (and merit, based on the instructor's judgement). For example, concerns that are shared by more than 50% of the class could require major changes or re-structuring of the course (or part of it), whereas concerns shared by only 10-20% of the class could require only minor adjustments and should be implemented only if those are to the benefit of the majority. This is determined through a discussion of the course evaluation results with the students, preferably in the next class right after the due date of the course evaluation survey. At that time, the instructor should take 10 minutes to present the findings of the survey, the most major comments, questions with the lowest ratings, and actions that will be taken to address the identified concerns. Based on the authors' experience, processing of the student responses does not take more than 1-2 hours.

A challenge that could be faced in implementing this course assessment model is a low response rate by the students to the surveys. The authors have addressed this issue by setting target response rates, in the range of 90% or 95%, and associating them with a bonus to the upcoming

midterm exams or the final student scores. In addition to achieving very high response rates, this strategy also instils a sense of responsibility to the students towards their peers and the class, because lack of responsiveness of few students could strip the bonus from the entire class.

Examples of common student concerns that can be (or have been) identified by these surveys include the general structure of the course (particularly for courses including labs and other components different from traditional instruction), the structure of the lectures (e.g., number of in-class examples, pace of the material presentation, relation of theory to real world problems and applications), the structure of the solution of in-class examples, the HW assignment length and format requirements, the relevance/closeness/correlation of the HW assignments to the lecture material and in-class examples, fairness in HW grading, the class environment, requirements of prior knowledge of the fundamentals, and the availability for office hours from the instructor and the TA.

Except for changes relating to the above student concerns, other notable major changes/upgrades that the authors implemented in their course organization over the years as a result of these assessment models include: (i) the modification of a laboratory component from the course on numerical methods and computer programming, which changed the attitude of the students towards computer programming, from "despising it" (quoted from a student response) to a "passion", (ii) the formulation of HW assignment preparation guidelines that address issues such as presentation, neatness, and structure, through several cycles of student feedback, and (iii) the structure of the posted notes to include "pre-lecture notes", i.e. a set of notes for the entire chapter, but without the solutions to the presented examples, to help the students prepare prior to classes, "problems/examples-only notes", i.e. a set of notes including only the problem questions and oversized figures to use in their solutions, and final "lecture notes" updated in accordance with the material presented in class, including problem solutions.

5 Results and Discussion

The proposed assessment model has been implemented by two faculty ("Instructor 1" and "Instructor 2") in two universities ("University A" and "University B") for both undergraduate and graduate courses over a time period of five years. The undergraduate courses include those of Statics, Engineering Mechanics: Dynamics, Structural Concrete Design and Computer Applications in Engineering and Construction. The graduate courses include Structural Dynamics, Advanced Mechanics of Materials, and Engineering Risk Analysis. Instructor 1 utilized the proposed assessment model to its full extent (Tables 1 through 6), whereas Instructor 2 (Tables 7 and 8) utilized the same model with a shorter version of the course evaluation questionnaires (2^{nd} and 3^{rd} survey). All data are presented in the tables below in the form of comparisons between course evaluation surveys, including mean values for all administered questions, percentage increases to quantify the achieved improvements, and *p*-values to provide a preliminary quantification of the statistical significance of the observed improvements. A two-sample double-tailed t-test with unequal variance and unequal sampled sizes was used to quantify the *p*-values, which represent the probability of obtaining results at least as extreme as the results actually observed by these comparisons, assuming that the null hypothesis is correct. Smaller *p*-values indicate a higher statistical significance, because they imply that the null hypothesis cannot explain the observed differences in the mean between the two samples. In this study, statistical significance is assumed to be referring to a significance level of 5%. It is

clarified that, although a more accurate statistical analysis that would account for proper probability distributions and sample sizes is possible, the analysis presented here is considered sufficient to identify trends within the context of this study.

According to these tables, the proposed assessment model clearly improves the quality of course instruction and learning environment during the semester and results in higher student satisfaction, particularly as this latter is reflected in the overall rating of the course and instructor (Q7/Q8 and Q16 in Tables 1 through 6, and several questions in Tables 7 and 8). Comparisons between the mean ratings from the 1st and 2nd course evaluation (2nd and 3rd survey of the model) show that these improvements are larger when the ***reference*** student ratings (i.e. the ratings of the first course evaluation) are below 80-85%, i.e. when there is a 15-20% room for improvement. In this case, the improvement in the *overall satisfaction for the course and the instructor* can exceed 15%, as shown by Q7 and Q16 in Table 1, Table 2 and Table 3, Q10 and Q18 in Table 4, Q8 and Q16 in Table 5, and Q9 in Table 7 and Table 8. These improvements, as is the case with all improvements exceeding 10%, are statistically significant ($p < 0.05$). This *overall satisfaction* is clearly tied to the *student learning* (or the confidence of the students in their understanding of the course material), which usually reaches or exceeds the improvements of the overall course and instructor rating (and with a statistical significance, $p < 0.05$), as shown by Q5 in Table 1, Table 2 and Table 3, Q8 in Table 4, and Q6 in Table 5. This is because students are more engaging and enjoy the course, when they feel they learn the material and can solve problems in HW assignments and exams. It is also observed that the achieved improvements are larger for large size classes (> 100 student), as shown by Q7 and Q16 in Table 2, as opposed to smaller size classes (< 50 students), as shown in Table 1, because the logistics and management of larger classes are more demanding and it is more likely that minor details of the course structure and delivery have consequences for more students, which, in turn, result in lower reference student ratings, leaving more room for improvement.

Furthermore, it is observed that the achieved improvements are larger (and show statistical significance) for courses taught for the first time (or only 1-2 times) by an instructor, which could naturally result in low reference student ratings (i.e. below 80-85% in the first course evaluation – 2nd Survey of the model), for which there is a larger room for improvement.

When the reference student ratings (i.e., first course evaluation – 2nd Survey of the model) exceed 90-95%, the proposed assessment model is not always capable of guaranteeing increases in the overall student satisfaction, because the room for improvement is small, as is the case for Statics – Spring 2015 (Table 1), Advanced Mechanics of Materials – Fall 2019 (Table 6), Engineering Mechanics: Dynamics – Spring 2019 (Table 7) and Engineering Risk Analysis– Fall 2018 (Table 8). This is because when a course structure and delivery has been well tuned for the class supermajority, any effort to address concerns of few students could dissatisfy other students. However, even in such cases, the reductions in student satisfaction are up to 3%-4% (or less), and are usually statistically insignificant ($p >> 0.05$), particularly when the overall student satisfaction remains above 90-95%.

From the tables below, it is also evident that in the first few years of applying this model, the authors faced the major challenge of occasionally low response rates to the surveys, which is also a challenge that most universities, including Universities A and B, have been facing. The authors

have addressed this challenge by setting target response rates, in the range of 90% or 95%, and associating them with a small bonus to the upcoming midterm exams or the final exam. This approach has indeed been successful in often achieving 100% participation (e.g. Table 4, Table 6 and Table 7). An alternative approach that the authors also used was to encourage students during and after class to submit their response to those surveys, emphasizing the importance of their voice being heard. This approach, despite proving efficient in increasing the student response rate (e.g. Table 1, Table 3 and Table 8), did not always achieve consistently high response rates. Overall, despite the low response rates at the early years of implementation of this evaluation model, the aforementioned major findings hold true and have been confirmed by recent implementations of this model for which consistently higher response rates have been achieved.

It is worth noting that the proposed assessment model has also resulted in overall improvements in student ratings *from semester to semester*, as shown in Tables 1, 2, 3, 4 and 7. However, such a trend is not always the case (e.g., Table 5), because courses are fine-tuned differently from semester to semester, and also evolve over time (beyond typical fine-tuning), revising their material and their delivery methods. For example, in one semester all HW submission can be in hardcopy vs. online in the next semester, which creates mixed feelings amongst students who are now required to scan their hand-written solutions or type them in a word editor. The proposed assessment model is designed to solicit timely student feedback and allowing optimal incorporation of such changes *within the semester*, but, by extension, it can guide refinements from semester to semester. In other words, the authors implemented in later semesters policies and strategies that they developed in previous semesters.

Table 1. Instructor 1 – University A – Undergraduate Course of Statics (CVEN 2121) – Smaller size classes (Max. Rating: 6)

		Statics - Spring 2014				Statics - Spring 2015			
		Evaluation 1	Evaluation 2	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	45				52			
	Response Rate	67%	53%			38%	62%		
Q1	COURSE: Rate organization of course content (syllabus, textbook, notes, D2L)	4.63	4.92	6.1%	0.248	5.3	5.53	4.4%	0.438
Q2	COURSE: Rate use of class time. Is the class time efficiently used to promote student learning?	4.43	4.46	0.6%	0.930	4.95	5.13	3.5%	0.542
Q3	COURSE: Rate the intellectual challenge of the course	4.27	4.67	9.4%	0.087	4.75	4.75	0.0%	> 0.999
Q4	COURSE: Rate quality of assigned HW. Does the assigned HW help you better understand the course material?	5.03	4.67	-7.3%	0.201	5.35	5.19	-3.0%	0.527
Q5	COURSE: Rate how much you have learnt in this course so far	3.87	4.42	14.2%	0.005	4.45	4.91	10.3%	0.100
Q6	COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning	4.67	4.96	6.2%	0.374	5.3	5.31	0.2%	0.962
Q7	**COURSE: Overall rating for the course**	**4.33**	**4.67**	**7.7%**	**0.139**	**5**	**5.22**	**4.4%**	**0.357**
Q8	INSTRUCTOR: Rate instructor's knowledge of the course material	5.40	5.63	4.2%	0.164	5.95	5.81	-2.3%	0.205
Q9	INSTRUCTOR: Rate instructor's presentation and explanation skills	4.60	4.50	-2.2%	0.707	5.3	5.22	-1.5%	0.741
Q10	INSTRUCTOR: Rate instructor's enthusiasm about the class	4.77	5.00	4.9%	0.358	5.4	5.44	0.7%	0.884
Q11	INSTRUCTOR: Rate instructor's effectiveness in encouraging interest	4.17	4.33	4.0%	0.590	5.05	5.03	-0.4%	0.949
Q12	INSTRUCTOR: Rate instructor's preparation for the class	5.27	5.42	2.8%	0.479	5.8	5.72	-1.4%	0.589
Q13	INSTRUCTOR: Rate instructor's availability for assistance	4.90	5.00	2.0%	0.715	5.4	5.38	-0.5%	0.900
Q14	INSTRUCTOR: Rate class learning environment and instructor-student Interaction. Does the instructor encourage this interaction inside and outside the class?	4.40	4.13	-6.3%	0.423	5.15	5.06	-1.7%	0.781
Q15	INSTRUCTOR: Rate instructor's respect and professional treatment of the students	5.30	5.00	-5.7%	0.404	5.55	5.50	-0.9%	0.849
Q16	**INSTRUCTOR: Overall rating for the instructor**	**4.67**	**4.75**	**1.8%**	**0.741**	**5.5**	**5.47**	**-0.6%**	**0.889**

Table 2. Instructor 1 – University A – Undergraduate Course of Statics (CVEN 2121) – Larger size classes (Max. Rating: 6)

		Statics – Fall 2015				Statics - Fall 2016			
		Evaluation 1	Evaluation 2	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	120				106			
	Response Rate	59%	53%			40%	30%		
Q1	COURSE: Rate organization of course content (syllabus, textbook, notes, D2L)	5.00	5.23	4.7%	0.079	5.48	5.25	-4.1%	0.264
Q2	COURSE: Rate use of class time. Is the class time efficiently used to promote student learning?	4.32	4.83	11.7%	0.024	5.29	5.13	-3.0%	0.506
Q3	COURSE: Rate the intellectual challenge of the course	4.87	4.69	-3.8%	0.257	4.93	4.78	-3.0%	0.427
Q4	COURSE: Rate quality of assigned HW. Does the assigned HW help you better understand the course material?	4.30	4.75	10.6%	0.025	5.38	4.72	-12.3%	0.002
Q5	COURSE: Rate how much you have learnt in this course so far	3.86	4.70	21.9%	< 0.001	4.69	4.69	-0.1%	0.990
Q6	COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning	4.62	5.22	13.0%	0.003	5.07	5.31	4.8%	0.370
Q7	**COURSE: Overall rating for the course**	**4.00**	**4.81**	**20.3%**	**< 0.001**	**5.07**	**4.88**	**-3.9%**	**0.402**
Q8	INSTRUCTOR: Rate instructor's knowledge of the course material	5.49	5.64	2.7%	0.269	5.83	5.69	-2.5%	0.214
Q9	INSTRUCTOR: Rate instructor's presentation and explanation skills	4.32	4.92	13.8%	0.003	5.17	4.91	-5.0%	0.316
Q10	INSTRUCTOR: Rate instructor's enthusiasm about the class	4.17	5.05	21.1%	< 0.001	5.31	5.22	-1.7%	0.734
Q11	INSTRUCTOR: Rate instructor's effectiveness in encouraging interest	3.49	4.58	31.1%	< 0.001	5.02	4.72	-6.1%	0.308
Q12	INSTRUCTOR: Rate instructor's preparation for the class	5.15	5.63	9.1%	0.001	5.64	5.66	0.2%	0.924
Q13	INSTRUCTOR: Rate instructor's availability for assistance	4.32	4.66	7.7%	0.133	5.12	4.72	-7.8%	0.123
Q14	INSTRUCTOR: Rate class learning environment and instructor-student Interaction. Does the instructor encourage this interaction inside and outside the class?	3.45	4.48	30.0%	< 0.001	4.93	4.75	-3.6%	0.511
Q15	INSTRUCTOR: Rate instructor's respect and professional treatment of the students	4.46	5.27	17.9%	0.001	5.64	5.22	-7.5%	0.069
Q16	**INSTRUCTOR: Overall rating for the instructor**	**4.10**	**4.91**	**19.7%**	**< 0.001**	**5.45**	**5.16**	**-5.4%**	**0.161**

Table 3. Instructor 1 – University A – Graduate Course of Structural Dynamics (CVEN 5111) (Max. Rating: 6)

		Structural Dynamics - Fall 2015				Structural Dynamics - Fall 2016			
		Evaluation 1	Evaluation 2	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	20				19			
	Response Rate	100%	80%			68%	53%		
Q1	COURSE: Rate organization of course content (syllabus, textbook, notes, D2L)	4.75	4.81	1.3%	0.837	4.77	5.60	17.4%	0.038
Q2	COURSE: Rate use of class time. Is the class time efficiently used to promote student learning?	4.7	4.94	5.1%	0.515	4.77	5.20	9.0%	0.296
Q3	COURSE: Rate the intellectual challenge of the course	5.15	5.31	3.2%	0.594	5.31	5.50	3.6%	0.652
Q4	COURSE: Rate quality of assigned HW. Does the assigned HW help you better understand the course material?	4.8	5.25	9.4%	0.115	4.77	5.30	11.1%	0.167
Q5	COURSE: Rate how much you have learnt in this course so far	4.5	4.88	8.3%	0.155	4.77	5.20	9.0%	0.243
Q6	COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning	4.7	4.50	-4.3%	0.661	4.69	5.20	10.8%	0.256
Q7	**COURSE: Overall rating for the course**	**4.45**	**5.06**	**13.8%**	**0.025**	**4.31**	**5.10**	**18.4%**	**0.005**
Q8	INSTRUCTOR: Rate instructor's knowledge of the course material	5.7	5.56	-2.4%	0.413	5.62	5.70	1.5%	0.688
Q9	INSTRUCTOR: Rate instructor's presentation and explanation skills	4.7	4.56	-2.9%	0.714	4.62	5.40	17.0%	0.050
Q10	INSTRUCTOR: Rate instructor's enthusiasm about the class	5.5	5.19	-5.7%	0.265	5.62	5.70	1.5%	0.745
Q11	INSTRUCTOR: Rate instructor's effectiveness in encouraging interest	5.05	4.63	-8.4%	0.288	5.08	5.10	0.5%	0.948
Q12	INSTRUCTOR: Rate instructor's preparation for the class	5.45	5.38	-1.4%	0.809	5.38	5.60	4.0%	0.460
Q13	INSTRUCTOR: Rate instructor's availability for assistance	4.75	5.00	5.3%	0.508	5.23	5.50	5.1%	0.381
Q14	INSTRUCTOR: Rate class learning environment and instructor-student Interaction. Does the instructor encourage this interaction inside and outside the class?	4.75	4.94	3.9%	0.644	5.38	5.60	4.0%	0.491
Q15	INSTRUCTOR: Rate instructor's respect and professional treatment of the students	5.25	5.38	2.4%	0.671	5.31	5.30	-0.1%	0.986
Q16	**INSTRUCTOR: Overall rating for the instructor**	**4.85**	**4.81**	**-0.8%**	**0.926**	**4.92**	**5.40**	**9.7%**	**0.134**

Table 4. Instructor 1 – University B – Undergraduate Course of Computer Applications in Engineering and Construction (CVEN 302) (Max. Rating: 5)

		Numerical Methods – Spr. 2018				Numerical Methods - Fall 2018			
		Evaluation 1	Evaluation 2	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	41				33			
	Response Rate	100%	88%			91%	100%		
Q1	COURSE: Rate organization of course content (syllabus, posted notes, eCampus, HW organization)	4.60	4.78	4.0%	0.100	4.67	4.79	2.6%	0.478
Q2	COURSE: Rate class preparation and organization (including Labs): Are the class activities well-prepared and organized	4.36	4.75	9.0%	0.005	4.70	4.82	2.5%	0.442
Q3	COURSE: Rate the intellectual challenge of the course	4.62	4.86	5.2%	0.061	4.43	4.73	6.6%	0.085
Q4	HW: Rate quality of assigned HW: Does the assigned HW help you better understand the course material and achieve the course objectives?	3.64	4.42	21.2%	0.001	4.20	4.55	8.2%	0.117
Q5	HW: Rate fairness in HW grading: Is the HW graded fairly and in accordance with the HW rules?	4.00	4.53	13.2%	0.007	4.03	4.91	21.7%	0.001
Q6	LABs: Rate quality of LAB Sessions: Do those sessions help you better understand the course material and achieve the course objectives?	3.74	4.42	18.2%	0.002	4.33	4.55	4.9%	0.312
Q7	LABs: Rate fairness in LAB grading: Are the Lab reports and codes graded fairly?	4.07	4.75	16.7%	< 0.001	3.67	4.88	33.1%	< 0.001
Q8	COURSE: Rate how much you have learnt in this course so far	3.90	4.39	12.4%	0.007	4.00	4.45	11.4%	0.022
Q9	COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning	4.43	4.56	2.9%	0.473	4.43	4.67	5.3%	0.238
Q10	**COURSE: Overall rating for the course**	**3.81**	**4.44**	**16.7%**	**0.001**	**4.47**	**4.79**	**7.2%**	**0.066**
Q11	INSTRUCTOR: Rate instructor's presentation and explanation skills: The instructor clearly explains the material so that I can understand it.	4.45	4.58	2.9%	0.348	4.50	4.79	6.4%	0.095
Q12	INSTRUCTOR: Rate instructor's enthusiasm about the class	4.90	4.94	0.8%	0.510	4.93	4.94	0.1%	0.937
Q13	INSTRUCTOR: Rate instructor's effectiveness in encouraging interest	4.33	4.61	6.4%	0.067	4.63	4.70	1.4%	0.725
Q14	INSTRUCTOR: Rate instructor's responsiveness: The instructor is open to my questions, and effectively answers them.	4.67	4.67	0.0%	> 0.999	4.87	4.85	-0.4%	0.902
Q15	INSTRUCTOR: Rate class learning environment: The instructor maintains a good learning environment for me.	4.36	4.61	5.8%	0.151	4.87	4.82	-1.0%	0.745
Q16	INSTRUCTOR: Rate instructor's availability for assistance: The instructor willingly makes time to help other students and me	4.55	4.72	3.8%	0.238	4.70	4.85	3.2%	0.270
Q17	INSTRUCTOR: Rate instructor's academic concern: The instructor seems to care that I learn this material.	4.64	4.75	2.3%	0.459	4.93	4.88	-1.1%	0.676
Q18	**INSTRUCTOR: Overall rating for the instructor**	**4.45**	**4.61**	**3.6%**	**0.254**	**4.80**	**4.88**	**1.6%**	**0.582**

Table 5. Instructor 1 – University B – Undergraduate Course of Structural Concrete Design (CVEN 444) (Max. Rating: 5)

		RC Design - Fall 2017				RC Design - Spring 2019			
		Evaluation 1	Evaluation 2	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	24				57			
	Response Rate	96%	63%			77%	77%		
Q1	COURSE: Rate organization of course content (syllabus, posted notes, eCampus, HW organization)	4.39	4.87	10.8%	0.016	4.50	4.84	7.6%	0.018
Q2	COURSE: Rate class preparation and organization: Are the class activities are well-prepared and organized	4.43	4.73	6.7%	0.109	4.18	4.66	11.4%	0.002
Q3	COURSE: Rate the intellectual challenge of the course	4.87	4.93	1.3%	0.519	4.82	4.70	-2.4%	0.269
Q4	HW: Rate quality of assigned HW: Does the assigned HW help you better understand the course material and achieve the course objectives?	4.43	4.73	6.7%	0.149	3.98	4.41	10.9%	0.016
Q5	HW: Rate fairness in HW grading: Is the HW graded fairly and in accordance with the HW rules?	3.39	4.33	27.8%	0.005	4.07	3.93	-3.4%	0.437
Q6	COURSE: Rate how much you have learnt in this course so far	4.17	4.67	11.8%	0.016	3.55	4.23	19.2%	0.001
Q7	COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning	3.22	4.33	34.7%	0.003	4.20	4.45	5.9%	0.172
Q8	**COURSE: Overall rating for the course**	**4.30**	**4.73**	**10.0%**	**0.021**	**3.86**	**4.43**	**14.7%**	**0.001**
Q9	INSTRUCTOR: Rate instructor's presentation and explanation skills: The instructor clearly explains the material so that I can understand it.	4.09	4.67	14.2%	0.006	3.86	4.52	17.1%	0.001
Q10	INSTRUCTOR: Rate instructor's enthusiasm about the class	4.83	4.93	2.2%	0.386	4.86	4.95	1.9%	0.194
Q11	INSTRUCTOR: Rate instructor's effectiveness in encouraging interest	4.52	4.73	4.7%	0.193	4.23	4.57	8.1%	0.044
Q12	INSTRUCTOR: Rate instructor's responsiveness: The instructor is open to my questions, and effectively answers them.	4.74	4.87	2.7%	0.384	4.41	4.77	8.2%	0.036
Q13	INSTRUCTOR: Rate class learning environment: The instructor maintains a good learning environment for me.	4.35	4.67	7.3%	0.146	4.14	4.66	12.6%	0.006
Q14	INSTRUCTOR: Rate instructor's availability for assistance: The instructor willingly makes time to help other students and me	4.70	4.80	2.2%	0.514	4.32	4.68	8.4%	0.037
Q15	INSTRUCTOR: Rate instructor's academic concern: The instructor seems to care that I learn this material.	4.87	4.87	-0.1%	0.983	4.68	4.95	5.8%	0.013
Q16	**INSTRUCTOR: Overall rating for the instructor**	**4.48**	**4.67**	**4.2%**	**0.322**	**4.07**	**4.64**	**14.0%**	**0.001**

Table 6. Instructor 1 – University B – Graduate Course of Advanced Mechanics of Materials (CVEN 633) (Max. Rating: 5)

		Advanced Mech. - Fall 2019			
		Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	38			
	Response Rate	100%	100%		
Q1	COURSE: Rate organization of course content (syllabus, posted notes, eCampus, HW organization)	4.95	4.95	0.0%	> 0.999
Q2	COURSE: Rate class preparation and organization: Are the class activities are well-prepared and organized	4.89	4.87	-0.5%	0.727
Q3	COURSE: Rate the intellectual challenge of the course	4.82	4.87	1.1%	0.536
Q4	HW: Rate quality of assigned HW: Does the assigned HW help you better understand the course material and achieve the course objectives?	4.66	4.55	-2.3%	0.458
Q5	HW: Rate fairness in HW grading: Is the HW graded fairly and in accordance with the HW rules?	4.74	4.66	-1.7%	0.632
Q6	COURSE: Rate how much you have learnt in this course so far	4.34	4.39	1.2%	0.727
Q7	COURSE: Rate effectiveness of electronic media (e.g., tablet, projector) to support student learning	4.82	4.89	1.6%	0.420
Q8	**COURSE: Overall rating for the course**	**4.71**	**4.66**	**-1.1%**	**0.691**
Q9	INSTRUCTOR: Rate instructor's presentation and explanation skills: The instructor clearly explains the material so that I can understand it.	4.61	4.71	2.3%	0.391
Q10	INSTRUCTOR: Rate instructor's enthusiasm about the class	5.00	5.00	0.0%	> 0.999
Q11	INSTRUCTOR: Rate instructor's effectiveness in encouraging interest	4.82	4.74	-1.6%	0.448
Q12	INSTRUCTOR: Rate instructor's responsiveness: The instructor is open to my questions, and effectively answers them.	4.95	4.92	-0.5%	0.649
Q13	INSTRUCTOR: Rate class learning environment: The instructor maintains a good learning environment for me.	4.97	4.84	-2.6%	0.195
Q14	INSTRUCTOR: Rate instructor's availability for assistance: The instructor willingly makes time to help other students and me	4.95	4.92	-0.5%	0.703
Q15	INSTRUCTOR: Rate instructor's academic concern: The instructor seems to care that I learn this material.	4.89	4.89	0.0%	> 0.999
Q16	**INSTRUCTOR: Overall rating for the instructor**	**4.95**	**4.79**	**-3.2%**	**0.123**

Table 7. Instructor 2 – University B – Undergraduate Course of Engineering Mechanics: Dynamics (CVEN 363) (Max. Rating: 5)

		Eng. Dynamics - Spring 2018				Eng. Dynamics - Spring 2019			
		Evaluation 1	Final	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	69				76			
	Response Rate	87%	91%			87%	91%		
Q1	Class Preparation: The class activities are well-prepared and organized	4.2	4.66	11.0%	< 0.001	4.94	4.83	-2.2%	0.072
Q2	Assignments: The examinations, assignments, projects, etc. aid me in achieving the class objectives.	3.93	4.56	16.0%	< 0.001	4.81	4.75	-1.2%	0.421
Q3	Communications: The instructor clearly explains material so that I can understand it.	3.88	4.48	15.5%	< 0.001	4.73	4.7	-0.6%	0.772
Q4	Responsiveness: The instructor is open to my questions, and effectively answers them.	4.02	4.52	12.4%	< 0.001	4.95	4.9	-1.0%	0.301
Q5	Academic concern: The instructor seems to care that I learn this material.	4.05	4.52	11.6%	< 0.001	4.92	4.92	0.0%	0.915
Q6	Availability: The instructor willingly makes time to help other students and me	3.88	4.45	14.7%	< 0.001	4.89	4.87	-0.4%	0.807
Q7	Fairness in Grading: The instructor is fair and consistent in evaluating my performance in the course.	3.87	4.56	17.8%	< 0.001	4.81	4.77	-0.8%	0.664
Q8	Environment: The instructor maintains a good learning environment for me.	4.05	4.48	10.6%	< 0.001	4.9	4.9	0.0%	0.953
Q9	**Overall Average**	**3.99**	**4.53**	**13.6%**		**4.87**	**4.83**	**-0.8%**	

Table 8. Instructor 2 – University B – Undergraduate Course of Engineering Mechanics: Dynamics (CVEN 363) (Max. Rating: 5) and Graduate Course of Engineering Risk Analysis (CVEN 699) (Max. Rating: 5)

		Steel Design – Fall 2017				Structural Risk – Fall 2018			
		Evaluation 1	Final	**Increase**	*p-value*	Evaluation 1	Evaluation 2	**Increase**	*p-value*
	No. of Students enrolled	24				26			
	Response Rate	58%	83%			77%	77%		
Q1	Class Preparation: The class activities are well-prepared and organized	4.14	4.65	12.3%	0.023	4.9	4.8	-2.0%	0.389
Q2	Assignments: The examinations, assignments, projects, etc. aid me in achieving the class objectives.	4.14	4.75	14.7%	0.007	4.8	4.35	-9.4%	0.047
Q3	Communications: The instructor clearly explains material so that I can understand it.	4	4.5	12.5%	0.019	4.55	4.2	-7.7%	0.139
Q4	Responsiveness: The instructor is open to my questions, and effectively answers them.	4.5	4.65	3.3%	0.403	4.95	4.85	-2.0%	0.305
Q5	Academic concern: The instructor seems to care that I learn this material.	4.36	4.65	6.7%	0.100	4.85	4.95	2.1%	0.305
Q6	Availability: The instructor willingly makes time to help other students and me	4.36	4.55	4.4%	0.280	4.95	5	1.0%	0.330
Q7	Fairness in Grading: The instructor is fair and consistent in evaluating my performance in the course.	4.29	4.65	8.4%	0.037	4.95	4.95	0.0%	> 0.999
Q8	Environment: The instructor maintains a good learning environment for me.	4.29	4.4	2.6%	0.613	4.9	4.8	-2.0%	0.467
Q9	**Overall Average**	**4.26**	**4.60**	**8.0%**		**4.86**	**4.74**	**-2.4%**	

6 Summary and Conclusions

This paper presents a *student-centered assessment model* that provides timely actionable feedback allowing optimization of course instruction during the semester with the goal of maximizing student learning and overall student satisfaction. The proposed model incorporates a structured approach that includes: (i) questions requiring numerical scores and open-ended questions to solicit student feedback, (ii) mechanisms to assess, address and implement that feedback, and (iii) methods to validate the success of the implemented improvements. The proposed model has been implemented in two universities and has been utilized by two faculty. Implementation of this assessment model resulted in an increase of the students' satisfaction within the semester (in terms of mean student ratings) and has led to long-term improvements in the instruction and overall organization of those courses.

A major advantage of the proposed assessment model is that it is easy to implement and requires minimal time from the instructor and the students, as it is applied at discrete time over the semester.

The proposed assessment model has been found to clearly improve the quality of course instruction and learning environment and results in higher student satisfaction. The improvements are larger (and statistically significant with a confidence level of 95%) when the reference student ratings (i.e. the rating of the first course evaluation – 2nd Survey of the model) are below 80-85%, mainly because there is a larger room for improvement. On the contrary, for reference student ratings exceeding 90-95%, the proposed assessment model is not always capable of guaranteeing increases in the overall student satisfaction (mean student ratings), because minor changes in the course design and delivery can have large consequences for the students. The achieved improvements were found to be larger for large size classes and for courses taught for the first time (or only 1-2 times) by an instructor. The overall student satisfaction about the course and the instructor was found to be correlated with the *perceived student learning* (i.e. the confidence that the students have in their understanding of the course material).

The authors' strategy of setting target response rates, in the range of 90% or 95%, and associating them with a small bonus to the upcoming midterm exams or the final exam, was found to achieve its goal, resulting in very high student participation in the course evaluation surveys, which are essential for the success of the assessment model.

The proposed assessment model, despite sharing some similar objectives with the Plus/Delta model [13], is different in that it is structured to not only identify areas of concern, but also to propose and implement improvement strategies, and moreover validate the success of the implemented strategies. Also, its surveys include a much more extensive list of questions to thoroughly assess various aspects of the course structure and delivery. Furthermore, unlike the Plus/Delta approach, this strategy does not require the students to explicitly state their contribution to their learning. Yet, such open ended questions could be added to the surveys of the proposed model in order to further help students realize their responsibility to their own learning.

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