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A Student-centred Approach to Improving Course Quality Using Quality Function Deployment*

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This paper presents the development and an application of a quality function deployment (QFD)-based methodology that will lead to increased student satisfaction with their educational experience in a redesigned course. The key elements of the approach are to obtain and categorize attributes that would constitute a good course, and an effective instructor from the students' point of view. Mapping these attributes to established pedagogies found in the literature, coupled with continuous assessment and refinement ensures that there is no mismatch between student and faculty expectations. The approach was successfully implemented in a first-year engineering design course that had previously undergone a major revision in content and delivery, which resulted in student dissatisfaction and very poor student evaluations at semester's end. Maintaining the new content, the QFD-based approach helped significantly increase student satisfaction with the course.

Keywords: QFD; engineering design

INTRODUCTION

OFTEN IN ENGINEERING, instructors focus more on what *they* believe is good for their students (and they are often correct), but do not adequately take into account the student's point of view on the instructional delivery methods and the entire educational experience. This often results in gaps or mismatches between student expectations and learning preferences, as well as faculty expectations and teaching preferences. However, as course quality is judged by the extent to which learning objectives are realized and the value students attribute to it, delivery is also an integral part.

Stedinger [1] illustrates how differences in student and faculty expectations, or gaps, can be overcome if faculty members help students to improve their articulation of what is and is not working for them. Similarly, Felder and Stice [2] state that students are better prepared to improve their learning environment when they understand and can articulate what is effective for them. Further, Anson *et al.* [3] observe that '[with a] diversity of approaches [to engineering education], the potential for mismatches between students' learning styles, preferences and practices on the one hand, and teaching pedagogies on the other, is considerable'. They go on to state, '. . . to understand and solve such mismatches requires seeing education as a . . . symbiosis involving complex relationships between students' and teachers' beliefs and practices'.

While we acknowledge that students are not adequately equipped to address broader learning objectives, appropriate course content and teaching methodology [1–4], we hypothesize that soliciting their opinion on what constitutes a good educational experience, and what instructional delivery methods they prefer (in their own words), and then mapping these attributes to appropriate teaching methodologies rooted in published best practices, should result in a better educational experience with improved learning outcomes. The objectives of this study, therefore, were to:

1. Develop an approach that views the students as 'the customer' who has paid for a 'service' that is delivered by the instructor. The approach is based on the Quality Function Deployment (QFD) method that has been modified to make it suitable for this application.
2. Ground the method on established best practices for improving course quality that are widely documented in the literature.

BACKGROUND AND MOTIVATION

This work was motivated by an initial unsuccessful content revamp of a first-year introductory engineering design course, *Introduction to Engineering Design (ED&G 100)*. The course underwent a major revision both in terms of delivery methods

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and content, and was piloted in two sections (out of 13 sections) in the 2004 Spring semester. ED&G 100 employs a design-driven curriculum with emphasis placed on skills such as teamwork, communication skills (graphical, oral and written) and computer-aided design and analysis tools. The course introduces first-year students to the engineering approach to problem-solving with strong references to basic science and maths skills, as well as testing and evaluation of design ideas by building models or working prototypes.

The major content change in the revised curriculum was an increased emphasis on hands-on design activities and the design process, embodied in two open-ended design projects. For Project 1, the instructor provided content information as needed while guiding the students step by step through the design process. Emphasis was placed on the acquisition of skills (for example, technical and graphical communication, teamwork, project management, etc.) and knowledge of the steps and the tools used in the initial stages of the design process (e.g. customer needs analysis, decision making, product dissection, patent analysis, concept generation methods). The second project focused on the transference of what was learnt in Project 1 to a more difficult design problem. Less guidance was provided and students were expected to apply their newly acquired skills and knowledge. In addition, students were exposed to additional design tools and topics such as the theory of inventive problem solving (TRIZ), materials and material selection, green design and engineering ethics. Each topic usually runs for about a week with students practicing their use in homework assignments first, and then directly apply them to their projects. The material is presented in a 'just-in-time' format vis-à-vis the projects, allowing the students to immediately apply what they have just learnt.

Despite all the good intentions of the revised curriculum, student course evaluations scores for each section were significantly lower than the mean of all 13 sections, and significantly lower than the values the authors typically receive for this course. The very low scores and general student dissatisfaction with the course provided motivation for this work.

THEORETICAL BASIS

The QFD method is widely used in industry where it is focused on delivering products and services that satisfy the customer, by listening to his and her voice throughout the product or service development process. QFD provides a set of tools and techniques that can be used to assure quality and customer satisfaction in new products and services [5, 6]. A central theme of QFD is customer satisfaction.

Customer satisfaction is a complex issue due to many potential variables impacting on a customer's point of view when developing a judgment related to a product. In order to lessen the complexity in understanding customer satisfaction Kano *et al.* [27] developed the Kano Model of Quality (see Fig. 1) with three curves representing expected, normal and excitement quality. Expected quality is the minimum quality in a product or service anticipated by the customer. It consists of items that a customer would not mention, unless it is absent. For example, one expects to purchase unspoiled milk—it 'goes without saying'. Selling fresh milk, therefore, will neither result in a satisfied nor a dissatisfied customer. However, spoiled milk or finding a product with an expired use-by-date would result in dissatisfied customers who would verbalize their displeasure. In the context of a learning environment, expected quality items from an instructor could include, showing up for class on time, being available during office hours, or legible handwriting on the blackboard. Although these items add to the overall course quality, their presence would not guarantee satisfied students, but their absence would lead to dissatisfied students.

Exciting quality refers to items that a customer would typically not verbalize as a need, but would get thrilled about if present. Their absence does not lead to customer dissatisfaction, but their presence yields excitement in customers. In an educational setting, an instructor may post all course notes online making them accessible to the students and providing a good source of materials, especially for poor note takers. Students who download and print the notes in advance of the class can then spend more time listening and understanding rather than feverishly keeping up with copying notes from the board. The availability of the notes before class is not what students would expect, but would certainly excite them once made available.

Finally, normal quality refers to items that the customer has expressed a desired need for in a product or service. As such, it leads to customer dissatisfaction if absent, and customer satisfaction if present. Because normal quality (a) is expressed by the customer, and (b) traverses the full spectrum from dissatisfaction to satisfaction, it provides the ideal dimension to employ in an educational setting to systematically improve a course and ensure that students are satisfied with their educational experience. We assert that for a specified course content (determined by faculty), learning outcomes will improve if students are satisfied with the delivery mechanism, and their entire educational experience during the course. The method presented in this paper, therefore, focuses on ensuring the presence of normal course quality, as expressed by students and interpreted within well-established pedagogical practices.

QFD has previously been applied in university settings, but primarily for the development of course or curricular content. In these studies, the relevant stakeholders, for example industry, students, and graduate schools were identified as

Fig. 1. Kano Model of Quality

the customer and their needs translated into QFD product features (*read* course content) such as communication skills, teaming skills, and technical knowledge [7–10]. Mazur [11] used QFD for both course design and improvement of delivery, for the latter using the students as the customers. He, however, charged a student group as part of their final project, to perform the QFD study and to suggest improvements to the instructor for implementation during the following semester.

Valuable surveys

Other studies have discussed different methods for using student input to improve instructional delivery and the educational experience. Stedinger [1] employed a Total Quality Management (TQM) approach based on ideas of customer focus, data-based decision making and continuous improvement, to a 100-student junior level probability and statistics course. Bi-weekly short, open- and close-ended surveys were employed to solicit student recommendations for effective teaching techniques they had seen in other classes and to comment on the extent to which current mechanical and motivational instructional approaches were working, or not. This approach is in line with other methods that employ the 'One-minute paper' to achieve the same. These methods, though very beneficial, focus more on the micro-level of instructional delivery (example comments include, 'cannot see bottom of screen', 'computer type is uniform and boring', 'give us time to complete notes') and rely on students to generate suggestions for improvement. In addition, the open-ended nature of the surveys does not allow for a statistical assessment of improvement in course satisfaction. Further they do not systematically incorporate pedagogies from the published literature, instead relying heavily on the instructor's own teaching philosophy.

The approach presented here focuses on the macro-level instructional delivery, with recommendations gleaned from best practices published in the literature. The use of both open-ended and closed-form surveys allows the elicitation of students' diverse views, as well as the statistical assessment.

Throughout, we use a modified house of quality (a central tool in QFD); this consists of the following sequential steps:

1. Perform a customer needs analysis (using surveys) to determine from the students *in their own words* what attributes they expect from a good instructor and what features/attributes they expect in a good course. In addition, have the students weigh the importance of the attributes.
2. Determine a comprehensive list of interventions from the published literature that can be used to improve various attributes of course quality or good instruction.
3. Determine correlations between the attributes put forth by the students and interventions to achieve them from the literature.
4. Set targets in order to quantify intervention outcomes.
5. Conduct assessment on a regular basis (e.g. we performed the survey three times a semester with one month intervals), to track how the instructor and the course are doing with respect to the attributes identified by the students in step 1. This step is crucial as it provides regular feedback from the students and allows mid-course corrections to be made (if necessary) that affect the current cohort of students, as opposed to end of semester course evaluations which do not.
6. Use the interventions complied in step 2 with the help of the correlations from step 3, to improve performance indicators of identified weaknesses. Provide feedback to the students on the assessment results, as well as the interventions to be used. This step helps the students feel empowered that they have input into the quality of their education, and that the instructor values and cares about their opinion.

This approach for improving course quality was applied during Autumn 2004 and Spring 2005.

Customer needs analysis

In our application of customer needs analysis, it was important to learn from the students what attributes they thought a good instructor and a good course should have. On the first day of the semester, the students were asked to complete the open-ended survey in Table 1. Open-ended surveys allow elicitation of in-depth information, especially when the subject is complex, and there are

Table 1. Open-ended survey instrument to capture the voice of the customer

1. What are your expectations of this course?
2. In general, what items/attributes do you expect from a good course?
3. In general, what attributes do you expect from a good instructor?
4. Do you prefer to work in teams or to work alone?
5. Do you prefer lectures or in-class hands-on activities?
6. As lectures **must** be given to some degree, what would be your ideal length (in minutes), past which you stop paying attention?

Table 2. Compiled student attributes for a good course and a good instructor

Good Course	Good Instructor
1. Informative	1. Organized
2. Fair learning environment	2. Well versed in subject matter
3. Challenging	3. Interested in subject matter
4. Open to student input	4. Interested in the success and work of students
5. Involves hands-on knowledge as well as knowledge in the fundamentals	5. Available
6. Involves students so that they are not just ears listening to the instructor go on and on	6. Makes the material easier to understand
7. Has a variety of activities	7. Is just and fair
8. Has structured teaching style	8. Outgoing and creative
9. Has material students can enjoy	9. Can communicate the subject matter well
10. Interesting	10. Lets students know what is expected of them
11. Provides a better understanding of the material	11. Accepts student input
12. Useful	12. Leads by example, not just by words

several avenues to explore [12], as is the case here. Despite the large number of attributes compiled from the customer needs surveys, they were readily grouped into twelve general attribute classes related to course and instructor quality (Table 2). More detailed lists, including sub-attributes, are displayed in Appendices I and II, respectively. The students' actual statements were included as the sub-attributes to give them and the instructor a complete understanding of each attribute. Duplicate statements were omitted.

The attributes expressed by the students in Table 2 were compared to and found consistent with the Chickering and Gamson's *Seven Principles of Good Practice in Undergraduate Education* [26]:

1. Communication with students
2. Teamwork and collaboration
3. Active learning
4. Prompt feedback
5. Time on task
6. Communicating high expectations
7. Respect for diverse ways of learning

One difference is that the seven principles provided above are general guidelines; students' 24 attributes provide more detail on expectations and therefore more direct ways to enhance the students' learning experience.

Compilation of instructional best-practices from the literature

Before the course started, the authors searched the engineering education literature for instructional best practices that might help improve both course delivery and student learning. Brief summaries of the best practices and their expected outcomes are presented in Table 3.

Finding qualitative correlations between best practices and student-identified attributes

A key tool of QFD is the House of Quality (HOQ) that contains qualitative correlations (strong, moderate, weak or none) between customer desires and technical requirements of the product or service. A modified HOQ was used to

Table 3. Summary of 'best practices' used to improve course delivery

Best Practice	Description	Findings or Expected Outcome
Teaching around the cycle [13–16]	Use of teaching methods that traverse all four learning styles of the Kolb model: divergers, assimilators, convergers, and accommodators.	Higher level of thinking and understanding.
Cooperative learning [17–19]	Students work in small groups throughout the semester. Consists of five basic elements: positive interdependence, face-to-face interaction, individual accountability and personal responsibility, collaborative skills, and group processing.	Most engineering students are visually-biased learners, as well as inductive and active. Typical lectures are passive and provide no opportunities for reflection on the presentation.
Active learning [20–22]	Introducing activities into the traditional lecture (breaks up the lecture) and promoting student engagement (activities designed around important learning outcomes and promote thoughtful student engagement).	Improved retention and student performance.
Inductive learning [1,13]	Integrating the course material with past learning experiences, previous courses or situations from everyday life. Starting with examples and experiences and working up to a general understanding.	A better understanding of course material. Connections of course material to the broader context of engineering in society.
Timely feedback [24–25]	Repeat exercise of a skill or application of a concept, followed by timely constructive feedback on the initial attempts.	Increase in level of mastery and understanding.
Teams-Games-Tournaments [23]	Employs team-based competitions to increase the cooperative nature of group projects and provide additional motivation to team members to perform.	Increase in academic achievement, understanding of subject matter, and peer tutoring.

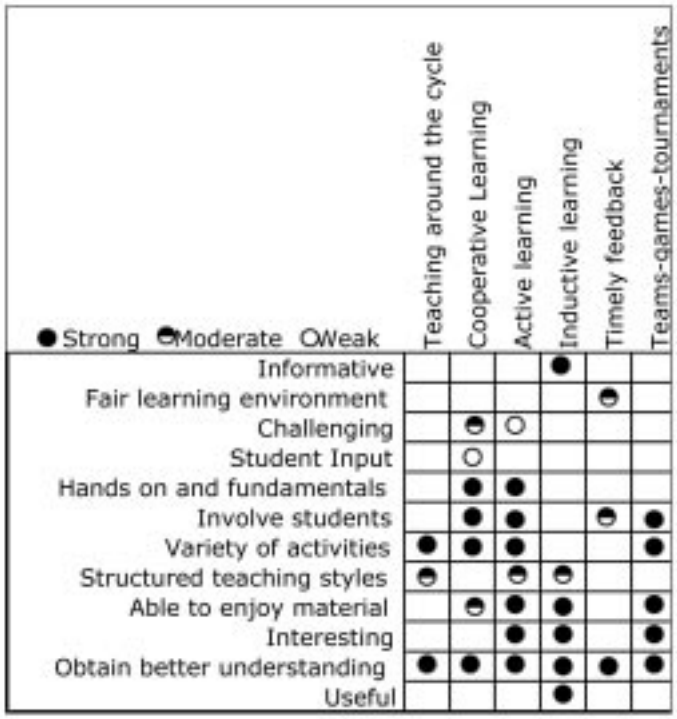


Fig. 2. Modified HOQ showing qualitative correlations between desired attributes in a good course and established pedagogies from the literature that might achieve them

obtain subjective correlations between the identified student attributes for a good course and instructional best practices obtained from the literature (Table 3). This HOQ application is shown in Fig. 2. Note that the attributes for a good instructor mostly were self-explanatory and therefore they were not placed into the HOQ.

Once the relevant pedagogies had been identified and the corresponding correlations established, the authors decided upon actual activities that would be immediately implemented to meet the student needs. A summary of these activities tabulated with the corresponding pedagogy is listed in Table 4. Only those activities that are different or modified versions from the previous semester are included. Needless to say, development of relevant activities using these guidelines continued throughout the semester.

ASSESSMENT OF THE COURSE DELIVERY ENHANCEMENT INTERVENTIONS

During Autumn 2004 and Spring 2005 students in both instructors' sections (total of four) were

Table 4. Brief summary of activities corresponding to best practices introduced to the course

Best Practice	Activity
Teaching around the cycle	All major concepts where taught through teaching around the cycle, by illustrating what and why in lecture, having the students practice the how in an in class exercise, and then having them apply the what-if to an open-ended problem, typically embodied in their design projects.
Cooperative learning	Student formed groups whose members sat next to each other in class and also worked with for group projects. Numerous in class activities were used including problem-solving, information gathering, laboratory exercises, etc., where the students worked in their groups. Teaming skills and exercises were also taught and practiced including project management, group personality assessments, etc.
Active learning	Previously all classes included a 30–50 min. lecture followed by group activity. All lectures broken down to 10–15 min. segments, with activities that bring out the learning objectives interspersed in between.
Inductive learning	Most lectures were preceded with a real world example or situation, and constant references were added to illustrate how the material learnt would be applicable in the future.
Timely feedback	Immediate feedback was provided for all in class activities, summarizing student results and correcting any misunderstood concepts. All assignments were promptly returned within a week. More detailed written feedback was provided on the assignments.
Teams-Games-Tournaments	An element of competition was added to both projects that were now peer-evaluated. Winning teams were treated to lunch by the course instructor.

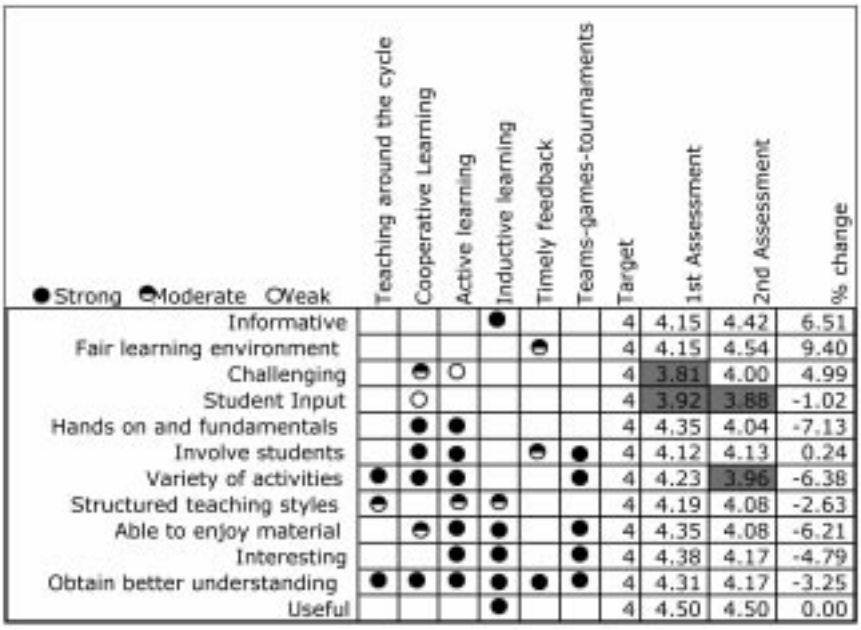


Fig. 3. Modified HOQ with the addition of target scores and Ogot's 1st and 2nd assessment scores

presented with closed-form surveys (shown in Appendices 1 and 2), where they were asked to rank on a 1–5 Likert scale (1-strongly disagree 2-disagree 3-neutral 4-agree 5-strongly agree) the extent to which the course and the instructor met each of the listed attributes. Closed-form surveys provide a practical method for obtaining statistically reliable conclusions because limiting the response choices allows for repeated data collection of attitudes over time [11]. For all attributes, both for the instructor and the course, target values were set at 4. A similar survey was conducted in the following semester, Spring 2005. Due to space limitations, however, only Ogot's survey results and experience are presented for Autumn 2004; similarly only Okudan's for Spring 2005. This is followed by comparison of student learning before and after the interventions for all sections. Finally, an analysis of the university administered course evaluations for both instructors from Autumn 2003 (before the new course content was introduced) to Spring 2005 (two semesters after the interventions) are presented and discussed.

Autumn 2004—Ogot

Two formative assessments were conducted during the Autumn 2004 semester, the first at the end of September (~ 4 weeks into the semester) and the second at the end of October. Results from the September course and instructor assessments are shown in Fig. 3 and Table 5. The course attribute assessments all exceeded the target score of 4 along all dimensions, except for 'Challenging' and 'Student Input'. As it was still early in the semester, the material was relatively easy and we expected that assessment regarding this attribute would increase as the semester progressed. For 'Student Input', we decided that more emphasis was needed on listening to students' points of view and on encouraging more dialogue in class. All instructor-related attribute assessments exceeded the target score, except for 'available', which had a low score of 3.77. This was quite puzzling given that the

Table 5. Mean scores from September and October surveys of student opinions on the extent to which Ogot met the 12 attributes of a good instructor

Dimension	Sept. Score	Oct. Score	% Change
1. Organized	4.54	4.58	1.0
2. Well versed in subject matter	4.73	4.75	0.4
3. Interested in subject matter	4.31	4.67	8.3
4. Interested in my success and work	4.23	4.50	6.4
5. Available	3.77	4.17	10.5
6. Makes the material easier to understand	4.35	4.46	2.6
7. Is just and fair	4.35	4.33	−0.3
8. Outgoing and creative	4.12	4.46	8.3
9. Can communicate the subject matter well to students	4.50	4.58	1.9
10. Lets us know what is expected of us	4.15	4.46	7.3

instructor had three hours of office hours each week (that no student had come to), and generally waited around after class until the last student left. However, it was decided to remind students about the office hours, ask them in class how they were doing, both one-on-one and as a class, and if they needed help with any aspects of the course.

For the October assessment course scores, the averages were slightly lower for most attributes, but the number of 'strongly disagree', 'disagree', and 'neutral ratings' drastically diminished. The lower averages are due to a sizeable number of ratings dropping from 'strongly agree' to 'agree'. This was not surprising as the course had become significantly more challenging at this point and more demanding of the students' time. However, nearly all measures remained above the target 4 score. As expected, the 'challenging' attribute went up, but despite the interventions there was a drop in the 'student input' score. Also, the 'variety of activities' score dropped to 3.96, but still very close to the target. Nearly all the instructor scores rose in the second assessment, most notably, the 'available' score, low in the September assessment (3.77), rose by 10.55% to 4.17.

As noted earlier, similar assessments and corrections were carried out in Okudan's section. Details are omitted due to space limitations. All Okudan's October scores, however, exceeded the set targets of 4.

Spring 2005—Okudan

Based on the success from the Autumn 2004 interventions, it was felt that only a single mid-semester assessment would be necessary. Again for the sake of brevity only the results and experiences from a single section, Okudan's in this case are presented. Mean assessment scores for the attributes of a good course and those of a good instructor are presented in Tables 6 and 7, respectively.

All scores except course attribute 'able to enjoy material' were above the target scores of 4. As the first step in improving the delivery, the average scores for all attributes were shared with students, and special attention was given to explaining that the 'able to enjoy material' attribute required improvement. Two small interventions were integrated into the course to increase the level of student enjoyment in the learning environment: (1) learning about materials with a 'magic show' opening, and (2) learning about engineering ethics and green design in an active, competitive environment. These just serve as examples of interventions that can be taken.

The magic show used a bolt-counting experimental setup, which requires participants to estimate the number of bolts in a plastic bucket (that is attached to a strain gauge and Wheatstone bridge circuit) without seeing how many were put in. Before the show, students were given the materials chapter from their textbook. During the show, two of them were selected to help. One put an unknown (to the instructor) number of bolts in the bucket; another reset the digital multi-meter and completed the necessary readings. Then, the instructor given the voltage reading was able to calculate the number of bolts and report to the class. When this was repeated 5–6 times, students were told: 'In your teams, discuss and report the properties of materials that made the magic show possible'. After 20 minutes meeting time, the instructor collected the reports, and then explained to the whole class what had been going on.

The other intervention focused on in-class facilitation of learning on two topics: engineering ethics and green design. Such topics, while very important to engineering students' development, often get limited attention. Because the middle of the semester is full of technical subjects, students feel 'virtuous' topics are not as important, and instructors mostly have difficulty in facilitating learning without sounding preachy. To encourage enjoyable learning an in-class competition was designed. The competition called on students to come prepared having read both topics from their textbook. On the competition day, instructor divided the classes into two groups, and wrote questions

Table 6. Mean scores from mid-semester surveys of student opinions on the extent to which Okudan met the *12 attributes of a good course*

Dimension	Score
1. Informative	4.40
2. Fair learning environment	4.47
3. Challenging	4.10
4. Student Input	4.12
5. Hands on and fundamentals	4.45
6. Involve students	4.33
7. Variety of activities	4.07
8. Structured teaching style	4.28
9. Able to enjoy material	3.92
10. Interesting	4.17
11. Obtain a better understanding	4.28
12. Useful	4.28

Table 7. Mean scores from mid-semester surveys of student opinions on the extent to which Okudan met the *12 attributes of a good instructor*

Dimension	Score
1. Organized	4.63
2. Well versed in subject matter	4.83
3. Interested in subject matter	4.75
4. Interested in my success and work	4.83
5. Available	4.45
6. Makes the material easier to understand	4.15
7. Is just and fair	4.33
8. Outgoing and creative	4.43
9. Can communicate the subject matter well to students	4.52
10. Lets us know what is expected of us	4.37
11. Accepts student input	4.33
12. Leads by example, not just words	4.38

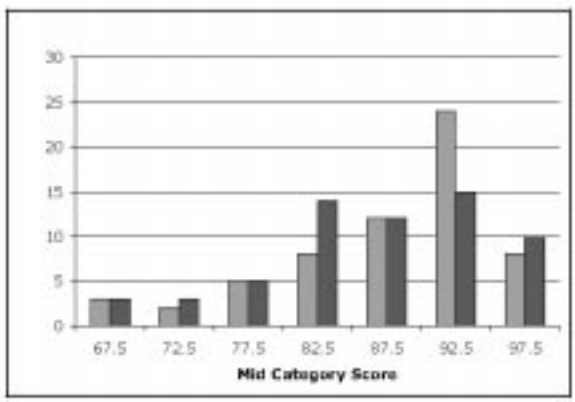
(one set of ethics and one of green design) on the board that needed to be answered by one of the teams. While the questions were being written on the board the competing groups talked about their strategy. For each question, while one group responded to questions in order, the other group acted as feedback providers. The instructor acted as the judge by deciding on the adequacy of answers and awarding the score (-1 for an incorrect answer, 0.5 for incomplete answer and 1 for a complete, correct answer). The responding team's response is first evaluated by the feedback providing team, and if the responding team cannot answer the question adequately the feedback providing team can answer and get the score for the question.

Until this point, we have only discussed the responses received to the surveys. However, understanding the level of effectiveness of the interventions introduced, we also need to compare student learning and overall student satisfaction with the course before and after the interventions. Accordingly, students' performance and course related judgments from the 2004 Autumn semester were compared with their 2004 Spring semester counterparts along two dimensions: (1) student learning (as measured by course exams) and (2) student satisfaction (as measured by course evaluations).

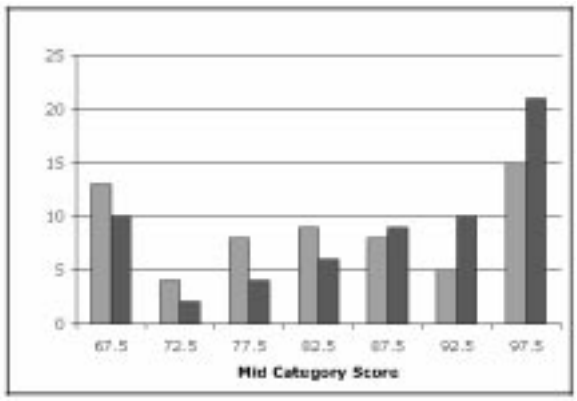
COMPARISON OF STUDENT LEARNING

Student scores from exams were used. Both classes took the same two exams (Exam I and Exam II) in each semester. Exam I was divided into two sections: design methodology (50%) and engineering communication via graphics (50%). Questions in the design methodology section sought to assess student learning on engineering design understanding, flow of the design process, various tools applied throughout the design such as customer needs assessment, Pugh Charts, analytical hierarchy process (AHP), project management techniques, etc. Questions did not require students to memorize textual information and regurgitate it during testing. Instead, questions focused on how design tools are used, for what purpose and in what sequence. Questions in the graphic communication section sought to assess student understanding and the application quality of communicating design ideas through manual sketching and drawings. Learning was assessed on correct applications of standards and conventions. For example, concept sketching, view placement standards, dimensioning, correct application of visible (object lines) and hidden lines, ability to visualize and sketch multiviews when given an isometric pictorial and vice-versa, etc.

Exam II was also divided into the same two sections with similar weights as for exam I. Topics in the design methodology section were similar to those in Exam I except for the addition of and emphasis on topics covered in the latter half of the semester: green design, materials and materials selection and engineering ethics. Section II, graphic communication focused on missing views, oblique and isometric drawings as well as an understanding of the topics covered in Exam I. Student scores for both sections for each semester from both exams were then compared. Figure 4 illustrates a comparison of score distributions between the two semesters for both exams. For Exam I, the mean scores were essentially the same. Table 8 gives the values of a t-test, indicating that the difference in scores between the two sets of students was not significant. As seen in the table, the calculated value for t is less than the critical value of t at the specified level of significance of α=0.05. For Exam II, the mean score for Autumn 2004 students' exam scores was 4.4% higher. Despite the increased mean score, a t-test found the increase in the average exam score not to be statistically significant for α=0.05 (Table 8). The exams given in Spring 2005 were different from those in 2004 and are therefore not used for comparison.



(a) Exam I



(b) Exam II

Fig. 4. Comparison of scores between students for the 2004 Spring and Autumn semesters

Table 8. Exam scores for students in Spring and Autumn 2004 classes used for t-test

Exam I	Mean	Standard deviation	Number of students	Calculated value of t	Degrees of freedom	Critical value of t
Spring 04	87.44	7.80	62	0.944	122	1.979
Fall 04	81.82	12.70	62			
Exam II						
Spring 04	86.01	8.86	62	1.516	122	1.979
Fall 04	85.41	13.48	62			

STUDENT SATISFACTION WITH THE COURSE

Students' overall satisfaction with the course was compared along 11 dimensions. A description of the dimensions and corresponding scores for students over a four semester period, Autumn 2003–Spring 2005, are given in Figs 5 (Ogot) and 6 (Okudan). With the inclusion of Autumn 2003 scores we can show student satisfaction with the course before the content revamp. Likewise, Spring 2004 scores demonstrate attitudes after the content revamp, and Autumn 2004 and Spring 2005 scores show the effect of the QFD-based delivery quality improvement. Scores were based on a Likert scale from 1 (strongly disagree) to 7 (strongly agree). For both instructors, the figures shows a dramatic increase in the scores between Spring 2004 and Spring 2005 in all dimensions, with overall course quality and overall instructor quality increasing by 47% and 64%, respectively for Ogot and 22.5% and 25.6%, respectively for Okudan.

A comparison of students in Autumn 2003 and 2004 classes also show an increase in student satisfaction across nearly all dimensions, with a 6% and 3% increase in course quality and instructor quality, respectively for Ogot and an 8.6% increase in course quality for Okudan with instructor quality returning to its original high score of 6.13. Further, this level of course and instructor satisfaction is maintained for both instructors in Spring 2005.

Improvements in desired outcomes after interventions have sometimes been attributed to the Halo effect, i.e. subjects show better outcomes as a

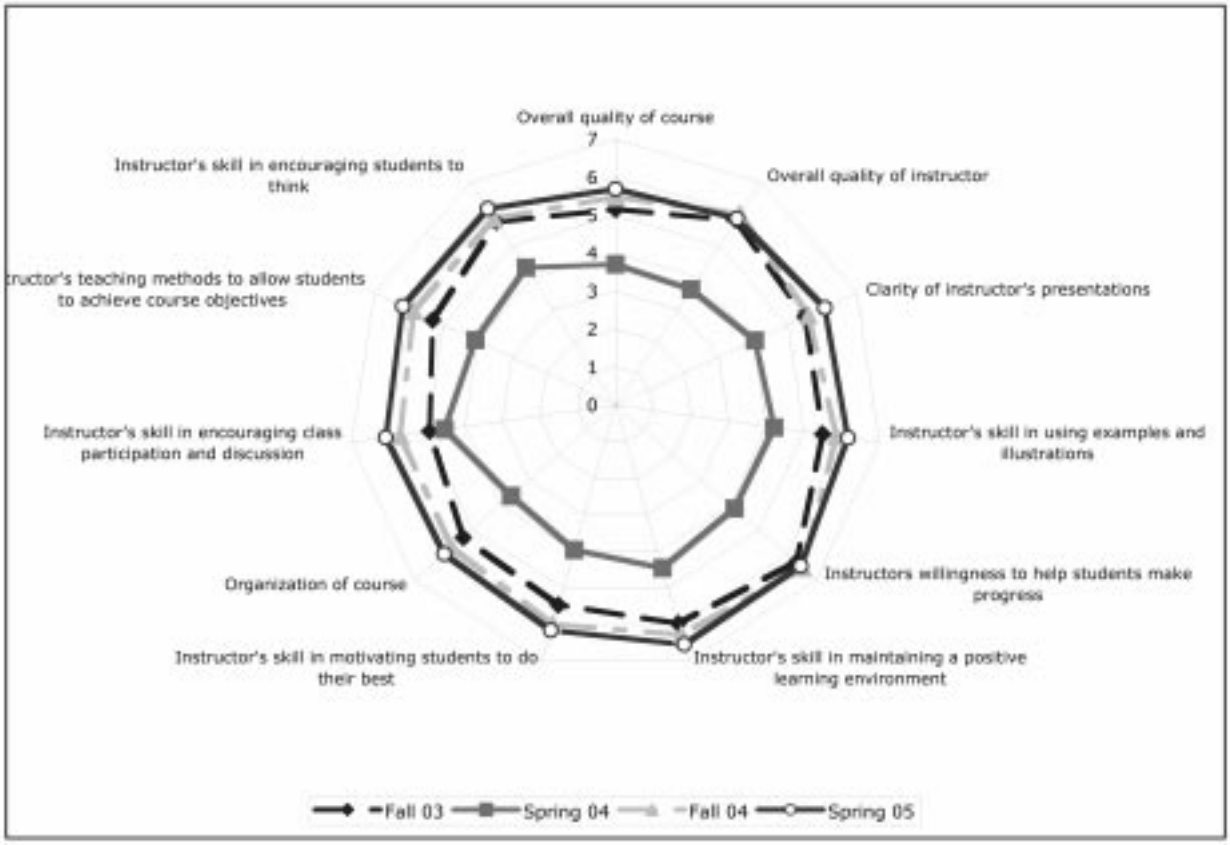


Fig. 5. Comparison of average scores of student attitudes measured along eleven dimensions for 2003 Fall semester, 2004 Spring and Fall semesters and 2005 Spring semester for Ogot. Ratings range from 1–7.

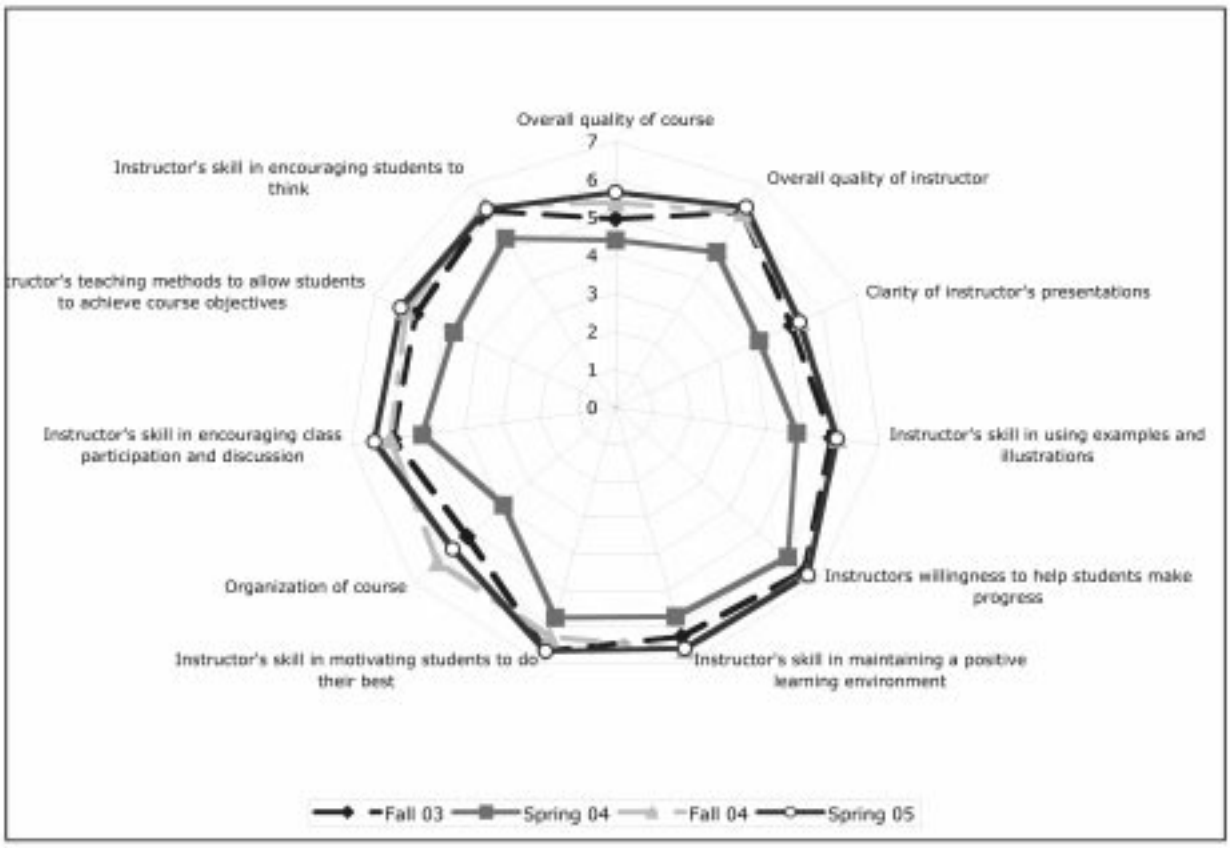


Fig. 6. Comparison of average scores of student attitudes measured along eleven dimensions for 2003 Autumn semester, 2004 Spring and Autumn semesters and 2005 Spring semester for Okudan. Ratings range from 1–7.

result of the increased attention they are getting and not so much from the introduced interventions. For this study each semester had a different cohort of students who could only assume that the way the course was taught, was the way it was always taught. Students were not aware of the genesis of the implementation of the QFD approach (i.e. student dissatisfaction in the Spring 2004 semester for both instructors), nor were they aware that it was part of a study, thereby discounting the increase in course and instructor satisfaction to be the result of the Halo effect. Further, the fact that both instructors saw a dramatic drop in student satisfaction after the new course content was introduced, and significant bounce back when using the QFD approach suggests that the approach does indeed capture the 'student needs', that when acted upon can result in increased student satisfaction.

DISCUSSION AND KEY CONCLUSIONS

The aim of this study was to develop an approach based on the QFD method to use appropriate pedagogies found in the literature that will lead to an increase in student satisfaction with their educational experience in a redesigned course. The key elements of the approach are to obtain and categorize in students' own words, attributes that would constitute a good course and a good instructor. Mapping these attributes to established pedagogies, coupled with continuous assessment and refinement ensures that there is no mismatch between the student and faculty expectations.

When implemented the first time, an inordinate amount of time was required to go through the literature, to find and understand how to use and adopt appropriate pedagogies. The student assessments themselves, however, required a minimal amount of time, about 10–15 minutes of class time twice in the semester. Compiling the first list of attributes from an open-ended survey took about an hour, and another hour to agree on the relevant pedagogies and qualitative correlations; obviously numerous hours had already been spent understanding the best practices. Compiling the two sets of assessment data required about 30 minutes each time. Implementing the approach a second time has been much easier as the assessment templates had already been established, and all classroom activities already designed. It is important still to assess the extent to which the instructor is meeting the students' expressed need to prevent the instructor from becoming complacent (teaching the same course over and over again), and to account for changes over time in student attitudes.

Given the assessment results provided above, we believe that the application of our approach proves our initial hypothesis, namely that soliciting student opinions on what constitutes a good educational experience, and what instructional delivery methods they prefer, then mapping these attributes to appropriate teaching methodologies rooted in published best practices, should result in a better educational experience for students.

Although student learning, as measured by two exams, did not show a statistically significant improvement before and after the QFD intervention (and certainly it did not decrease), the pre-intervention aggregate scores, which were already high, left little room for significant gain. What *is* shown is that student satisfaction can be increased without watering-down course content and rigour. Increase in student satisfaction should not be underestimated, especially for courses taken early on in a student's academic career, as this can influence other educational factors such as retention rates.

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APPENDIX I

Compilation of student views on the attributes of a good course

	Score
1 Information	
Learn something that will stay with me for many years Provides current information To use the knowledge gained in the good course and be able to apply it to real life situations and other courses Good content Knowledge obtained from course be accurate and up to date Course that teaches through real life experiences Relates contemporary problem solving to fundamental skill sets Ability to meet or exceed all objectives of course	
2 Fair learning environment	
3 Challenging	
Homework is useful and requires effort but is not overwhelming To be challenging but not ridiculous Challenge my mind and take my thinking skills and work habits to the next level Challenging but not insanely hard Comprehensive but not excessive classwork	
4 Student Input	
A two side affair and not always controlled by the instructor There should be flow of thought from both sides Curriculum that is responsive to student ideas Involvement of students	
5 I expect hands-on knowledge as well as knowledge in the fundamentals	
Good balance of lecture time and hands on work Information should be presented through lectures so that they can try it in the lab portion	
6 Involve students so that they are not just ears listening to the instructor go on and on	
A curriculum that is interactive	
7 Variety of activities	
A change in the norm, not always doing the same old thing	
8 Structured teaching style	
Time in class is used effectively Moves at a steady pace Well taught lectures Clear instruction	
9 Ability to enjoy the material brought forth in the course	
Ability to remember almost everything taught Fun, not always serious, but structured Fun, good atmosphere Enjoyable	
10 Interesting	
I like when the material learnt is interesting To stay on the central topic but have enough diversions to keep the subject interesting Just thorough information, but not too much to bore me	
11 Obtain a better understanding of the material	
Forces you to learn, but helps you learn it	
12 Useful	
Use it later in my career Take away more than just the skills from the course Course that can change the way you look at people Course that can change the way you work with people You are learning stuff that will help you be more successful in the future	

APPENDIX II

Compilation of student views on the attributes of a good instructor

	Score
1 Organized	
Informed, prepared instructor Gives targetted lectures on point	
2 Well versed in the subject matter	
Understanding of subject material Expert in the field Knowledgeable She/He must know what he is talking about	
3 Interested in subject matter	
Excited about the topic Enthusiasm Energetic	
4 Interested in my success and work	
Someone who is approachable Patience Someone who can teach me about myself as well as the subject Willing to help students learn Someone who is understanding Someone who cares about the well-being of their students Wanting the student to learn Does not hand feed us the information Someone who wants to see their students succeed and will do all they can to see this happen Show students how to [achieve] and eventually lead the students past their goals and objectives Someone who will push me but not drive me into the ground	
5 Available	
Take time to help students who want to be helped She/He should be available for assistance when necessary Has a lot of help sessions for students	
6 Makes the material easier to understand	
She/He should explain the problem and solution thoroughly	
7 Is just and fair	
Tough but fair Clear and fair Understanding Reasonable Realizes that this is not the only class I am taking and assigns work accordingly	
8 Outgoing and creative	
Down to earth Someone who is personable A good sense of humour and entertaining personality always works too	
9 Can communicate the subject matter well to students	
Ability to be heard Communicate subject matter in an interesting way Presents the material well Attention holding—sometimes grabbers are too over the top Present information in an interesting manner New and unique way to present the information necessary A way to maintain interest in the subject Someone who can keep my attention Should appeal to the classes learning style Good communicator Intelligent coherant professor Interesting/Not too dull Clear instruction	
10 Let us know what is expected of us	
Provides timely feedback on work turned in	
11 Accepts student input	
Give ideas and listen to yours Is open to different opinions about a topic that does not have concrete meaning	
12 Leads by example, not just by words	