

AC 2009-555: EFFECTIVE CRITERIA FOR TEACHING AND LEARNING

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Effective criteria for teaching and learning

New faculty as well as experienced faculty may sometimes face challenges concerning teaching evaluations. Student perception of what is taught and what is learned may be significantly different from the instructor's perception and intention. This may become a problem, since education institutions often use student evaluations of teaching as an important criterion for tenure, promotions, retention, or salary raise purposes. The argument goes that student ratings do not help instructors improve their perception of a class unless supported by professional advice. The questions that tend to be of special interest during the evaluation process are: "the course as a whole was...?"; "the course content was...?"; "the instructor's contribution to the course was...?"; "the instructor's effectiveness in teaching the subject matter was...?". In a previous study, we identified that, in fact, engineering students reacted to *more particularly defined criteria* associated with each question. Those criteria are confirmed by the present study and a quantitative measure can be established for them. A new hierarchy of the student perceived criteria is developed. We show that the SET questions are not testing independent variables but rather correlated ones. A strong correlation between three out of four SET questions has been confirmed and quantitatively assessed. We also report that students reveal triggering factors that override their normal criteria for assigning SET scores.

Authors are hopeful that the study may be of interest to new and established engineering instructors. Furthermore, in order to increase the relevance of our conclusions we are planning to use this pilot study as a guideline for a broader research to be conducted at a handful of universities involving different engineering disciplines.

1. Introduction

It is now generally acknowledged that the quality of education needs to be increased. While understanding students' needs, instructors should fulfill them without compromising curriculum and educational goals. Effective criteria for teaching and learning are of interest to every instructor. However, the concepts of "effective teaching" and "learning" may often have different meanings for instructors and students. The effectiveness of the teaching and learning process is routinely evaluated by students with the purpose of making the teaching process more efficient. Student evaluations of teaching (SET) achieved by answering a standard or specific questionnaire is always a good feedback about students' perception of the quality of instruction. As SET scores are often used for tenure, promotions, retention, and salary raise purposes they do have significant meaning for instructors. New faculty particularly may be well prepared scientifically but have little or no instruction on psychological issues related to teaching. Although at first glance it appears that the feedback will help instructors improve their class performance, studies show that student ratings are of little help to instructors if not supported by professional advice [1]. This demonstrates that students and instructors have different perceptions relative to instructional activities, which requires a scrutiny of students' perception and reaction to specific standard questions.

Based on data collected at the University of Washington, Gillmore [2] supports the view that adequate instructor reliability rating is achieved in certain circumstances but is limited to similar conditions of measurement. On the other hand, SET scores may not be as reliable as they are thought to be, as some studies show that instructors can increase

SET scores by inflating grades or grade expectations [3-7] (even if some corrections may be applied in order to rectify the results [8]). The fact that the quality of instruction is not necessarily correlated to SET scores was strongly opposed particularly in the 1970's [9]. Other general concerns related to how SET ratings are actually used have been investigated in the literature [10].

Our contribution to the investigation of SET as a measure of the quality of instruction is related to what we consider as the source of SET responses, namely the students' relative short term perceptions and reactions to specific instruction. We focused on our engineering students' perspective on effective teaching and learning in an attempt to identify the variables involved in their perception related to SET questions [11]. The survey was conducted in a 200-level electrical engineering class of 26 students. Students were asked to give their sincere opinion on the practical factors contributing to their numerical SET scores. The questions of interest are given in Table 1.

Table 1. SET questions investigated

Q1:	“the course as a whole was...?”
Q2:	“the course content was...?”
Q3:	“the instructor's contribution to the course was...?”
Q4:	“the instructor's effectiveness in teaching the subject matter was...?”

Following the analysis of the survey data, relevant factors were identified [11] specifically for each question Q1-Q4 (please see Tables 2 to 5). These identified subjective factors were ordered according to the frequency of received answers. However, the frequency of their appearance in the survey does not tell anything about their perceived weight on student perception. Their precise relative weight could not be estimated from the data in [11]. The analysis also suggests that Q1, Q3, and Q4 do not test independent variables but rather correlated ones. Nevertheless, the degree of correlation for the three questions could not be estimated.

The present study particularly addresses the above mentioned issues in [11] and attempts to determine a quantitative relative weight of the subjective factors identified. A quantitative degree of correlation among Q1, Q3, and Q4 is also attempted now. This study comes as a second step, with the purpose of confirming, consolidating, and refining the initial conclusions derived in [11].

2. Data collection and processing

The identified subjective variables related to each SET question (Table 1) as resulted from [11] are shown in Tables 2 to 5 and they are arranged with their highest frequency of appearance first. Little is known about the importance (weight) the students assign to these criteria. In order to confirm the validity of the results in [11] as well as to assess the relative weight students that perceive in these items a similar class of 200-level electrical engineering class (22 students) was surveyed one year later. The four questions in Table 1 were given to the students, together with the possible reasons influencing their decision in assigning SET scores for each different question. Students were informed that the survey was absolutely voluntary and anonymous, that it would not affect them in any way, and that their sincere input was needed. Students were asked to assign a relative

percentage weight to each of the reasons presented (if appropriate) for each question or add different reasons so that the sum for each question is 100%. The survey also included a question asking for specific trigger reasons (if any) for assigning high or low scores to the four SET questions, irrespective of whatever reasons may normally be used. Twenty students out of twenty two were present at the time of the survey and nineteen provided numerical answers.

Surveys were collected and data was compiled and analyzed. On a few occasions students did not correctly add up percentages to 100% but rather 97% or 105%, for instance. For those cases, percentages related to each reason initially assigned to a question were recalculated by scaling the original ones to the total/resultant percentage sum. The number of numerical responses (other than 0%) were counted for each SET virtual reason specified (please see Fig.2, Fig.4, Fig.6, and Fig.8). Common sense makes us believe that there is some kind of proportionality between the subjective weight of a perceived SET decision factor and the assigned SET score. Hence, the average weight of a certain factor for the class, *although not perfect, would still give an approximate quantitative measure of its weight*. Therefore, an average percentage, student assigned weight was calculated for each provided reason/factor from Table 2 to Table 5. The subjective factors given were then sorted according to their average value for each question (please see Fig.1, Fig.3, Fig.5, and Fig.7).

Table 2. Student identified criteria for Q1.

Q1_1	student feels that he is learning as opposed to wasting time
Q1_2	instructor's teaching style
Q1_3	clarity and organization of the course
Q1_4	grading techniques
Q1_5	perceived course challenge (easy/difficult)
Q1_6	instructor is available and helpful
Q1_7	instructor's personality
Q1_8	course is enjoyable/ fun
Q1_9	course environment
Q1_10	amount of work requested for the course
Q1_11	instructor's knowledge of the subject
Q1_12	course is informative and useful
Q1_13	course is interesting
Q1_14	class experience

Table 3. Student identified criteria for Q2.

Q2_1	the material taught was useful/relevant
Q2_2	perceived course challenge: good
Q2_3	course is interesting
Q2_4	perceived course challenge : bad
Q2_5	course was "well taught"
Q2_6	student was able to learn
Q2_7	textbook: good/bad
Q2_8	content taught is relevant to tests
Q2_9	student expectation about course learning outcomes

Table 4. Student identified criteria for Q3.

Q3_1	instructor is available and helpful
Q3_2	clarity and organization of the course
Q3_3	instructor's knowledge of the subject
Q3_4	instructor is enthusiastic/ enjoys teaching
Q3_5	instructor presents additional information not found in the text
Q3_6	instructor can answer questions well
Q3_7	instructor uses technology (such as Blackboard)
Q3_8	instructor uses interactive methods
Q3_9	instructor cares about student learning
Q3_10	always gives the same score (3 out of 5)

Table 5. Student identified criteria for Q4.

Q4_1	clarity and organization of the course
Q4_2	instructor teaches at student level / makes it easy to understand
Q4_3	student's personal understanding of the concepts taught
Q4_4	instructor's knowledge of the subject
Q4_5	instructor can answer questions well
Q4_6	class opinion
Q4_7	grade in the course
Q4_8	instructor links content to practical applications

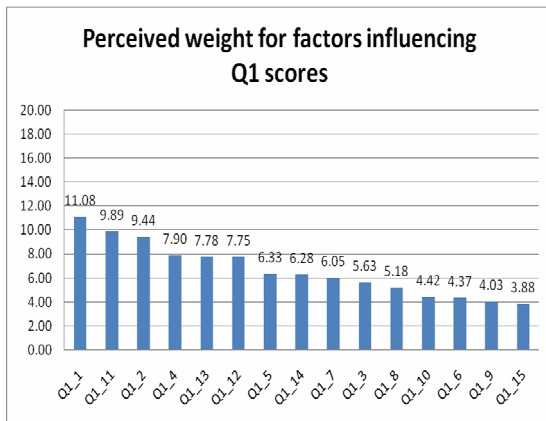


Figure 1 Student-perceived weight (%) for Q1

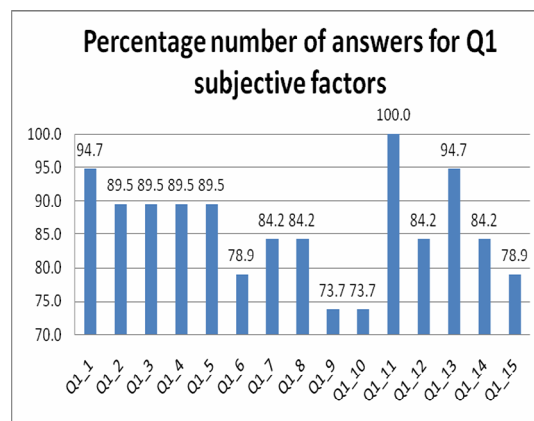


Figure 2 Number of student responses (%) for Q1

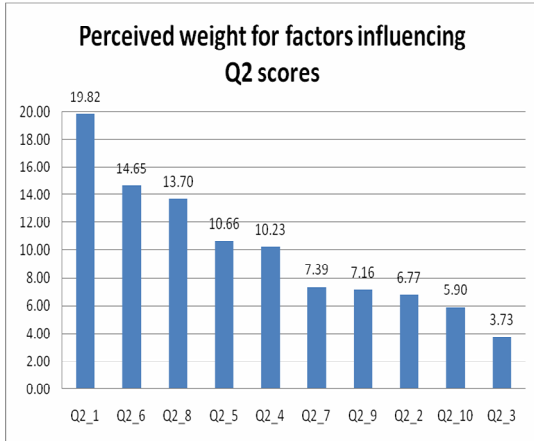


Figure 3 Student-perceived weight (%) for Q2

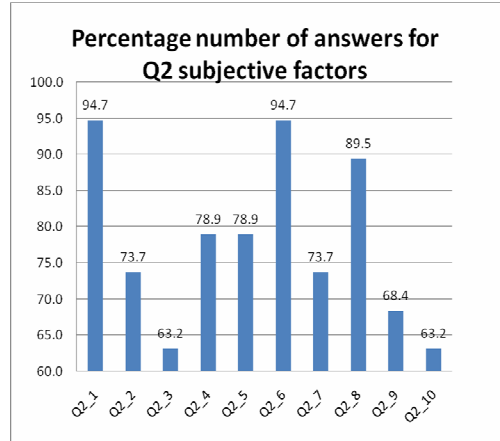


Figure 4 Number of student responses (%) for Q2

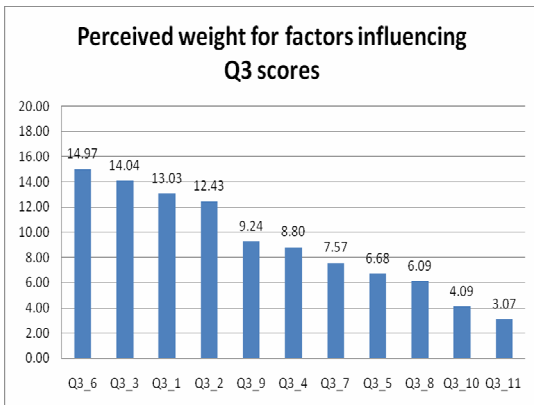


Figure 5 Student-perceived weight (%) for Q3

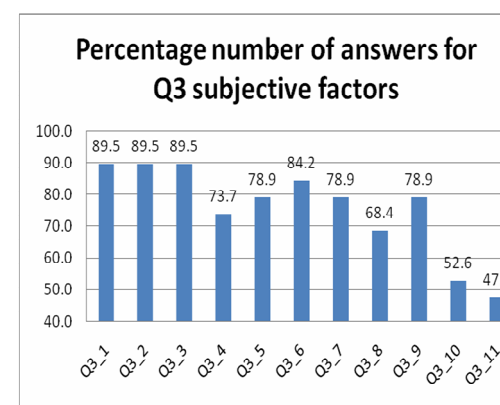


Figure 6 Number of student responses (%) for Q3

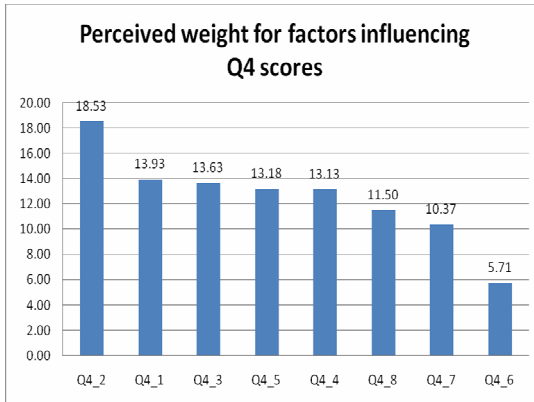


Figure 7 Student-perceived weight (%) for Q4

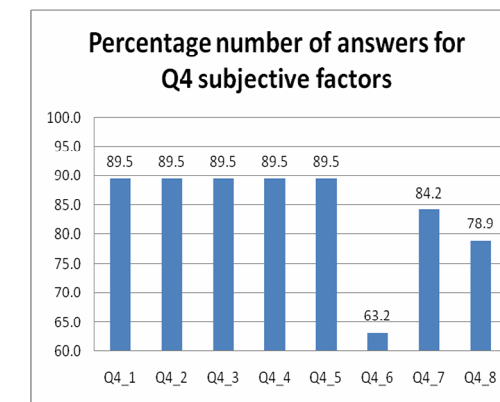


Figure 8 Number of student responses (%) for Q4

3. Data Analysis

The following remarks are pertinent for the processed data:

Question 1 (Q1)

It is noticeable that according to our data analysis the factor that surfaced as having the highest importance/ weight related to Q1 is that “student feels that he is learning as opposed to wasting time”. This also coincides with the fact that according to the previous analysis in [11], it was recorded as having the highest frequency. However, the next in

line as importance are “instructor's knowledge of the subject” and “instructor’s teaching style,” which change the order from the previous classification. After examining the ordering of factors according to their initial frequency and to their student-assigned relative weight, we found potentially significant differences (although not from the perspective of a rigorous statistical analysis). It is noticeable that the influence of colleagues’ opinions relative to the quality of instruction is the least relevant factor not only for assessing Q1 but for the rest of the questions as well. It is interesting that “instructor is available and helpful” and “amount of work requested for the course” are clustered in the lower relevant segment of the factors related to Q1. If we examine the percentage contribution of particular factors to making SET scores for Q1 (Fig. 2) a striking fact is that most students matched the choice of their colleagues who took this class the previous year and assigned a numerical weight to their factor choice.

Table 6. Hierarchic order for student criteria employed for Q1.

#	%	Q1: “the course as a whole was...?”
1	11.08	student feels that he is learning as opposed to wasting time
2	9.89	instructor's knowledge of the subject
3	9.44	instructor's teaching style
4	7.90	grading techniques
5	7.78	course is interesting
6	7.75	course is informative and useful
7	6.33	perceived course challenge (easy/difficult)
8	6.28	class experience
9	6.05	instructor's personality
10	5.63	clarity and organization of the course
11	5.18	course is enjoyable/ fun
12	4.42	amount of work requested for the course
13	4.37	instructor is available and helpful
14	4.03	course environment
15	3.88	class opinion

Question 2 (Q2).

It is also noticeable that according to the present analysis the factor that surfaced as having the highest importance/ weight related to Q2 coincides with the one with one of the highest frequencies in the previous study: “the material taught was useful/relevant”. Nevertheless, the other remaining factors do not follow the frequency factor. Part of the most important criteria for Q2 includes “student was able to learn” and “content taught is relevant to tests”. It is interesting to notice that a “good” perception of the course challenge appears almost twice more important than if the perception of the course challenge was “bad”. Most of the students recognized the given factors as their own, with a particular weight in making their decisions. Fewer students (63.2%) considered that their SET scores for Q2 are influenced by the fact that “the course is interesting” or by peer opinion. This is in agreement with the “class opinion” ranked as the last but one in importance. However, “course is interesting” has much more relevance/weight for those sensitive to it, as it scores somewhere in the middle among Q2 factors (10.23%).

Table 7. Hierarchic order for student criteria employed for Q2.

#	%	Q2: “the course content was...?”
1	19.82	the material taught was useful/relevant
2	14.65	student was able to learn
3	13.70	content taught is relevant to tests
4	10.66	course was "well taught"
5	10.23	course is interesting
6	7.39	textbook: good/bad
7	7.16	student expectation about course learning outcomes
8	6.77	perceived course challenge: good
9	5.90	class opinion
10	3.73	perceived course challenge : bad

Question 3 (Q3).

The most frequent factor initially reported for Q3 was “instructor's knowledge of the subject” which came only second (after “instructor can answer questions well”) according to the present classification. “Instructor is available and helpful” and “clarity and organization of the course” are following closely within the segment of top factors regarding Q3. Although within the lowest important range, slightly more than half of the class agrees (Fig. 6) that there are situations when they always give the same score for Q3. Also, slightly less than half of the class perceives that their colleagues’ opinion matters for assigning scores to Q3. The top four reasons identified account for 55% of the weight compared with only about 20% for the four bottom factors.

Table 8. Hierarchic order for student criteria employed for Q3.

#	%	Q3: “the instructor's contribution to the course was...?”
1	14.97	instructor can answer questions well
2	14.04	instructor's knowledge of the subject
3	13.03	instructor is available and helpful
4	12.43	clarity and organization of the course
5	9.24	instructor cares about student learning
6	8.80	instructor is enthusiastic/ enjoys teaching
7	7.57	instructor uses technology (such as Blackboard)
8	6.68	instructor presents additional information not found in the text
9	6.09	instructor uses interactive methods
10	4.09	always give the same
11	3.07	class opinion

Question 4 (Q4).

The most relevant factor came to be “instructor teaches at student level / makes it easy to understand”. This criterion “tops” by almost 5% the leading segment of another four criteria centered at about 13.5%. Remarkable for the resultant order of the student-reported factors related to Q3 is that little variation from the initial (frequency-based

order) was achieved. With the exception of the “class opinion” criterion the remaining seven criteria were by maximum one order off from the initial order. The class opinion again matters the least to students. The majority of students acknowledge the proposed criteria as their own. The criterion least agreed on (only 5.71% of the students) is “class opinion”.

Table 9. Hierarchic order for student criteria employed for Q4.

#	%	Q4: “the instructor's effectiveness in teaching the subject matter was...?”
1	18.53	instructor teaches at student level / makes it easy to understand
2	13.93	clarity and organization of the course
3	13.63	student's personal understanding of the concepts taught
4	13.18	instructor can answer questions well
5	13.13	instructor's knowledge of the subject
6	11.50	instructor links content to practical applications
7	10.37	grade in the course
8	5.71	class opinion

Other Remarks

It was showed [11] that Q1, Q3, and Q4 do not test independent variables but it was not possible to assess at what level these variables are correlated. As our present investigation could reveal, to a certain extent the weight students assign to different factors influencing their decisions makes a certain estimate of this correlation possible:

- Questions Q1 and Q4 have three common criteria shown in Table 10. The common criteria account for about 20% relevance for Q1 and about 30% for Q4 (i.e. the same criteria for Q3 are about 1.5 times more relevant for Q1).
- Questions Q3 and Q4 have three common criteria shown in Table 11. The common criteria account for about 45% relevance for both Q3 and for Q4.
- Questions Q1 and Q4 have three common criteria shown in Table 12. The common criteria relevance for Q3 are almost twice more important for Q1 (they account for about 24% relevance for Q1 and about 43% for Q3).

The comparison clearly shows that Q3 and Q4 are strongly correlated from the students' perspective. The top factors having the heaviest influence on student perceptions are “instructor's knowledge of the subject”, “clarity and organization of the course”, “instructor can answer questions well”. Clearly these factors are all defining the quality of instruction perceived by students. Nevertheless, they only account for an overall weight of 27% of all the four questions.

Table 10. Comparison of common student perceived criteria for Q1 and Q4.

Q1 (%)	Q4 (%)	Subjective common factors for Q3 and Q4
9.89	14.04	instructor's knowledge of the subject
5.63	12.43	clarity and organization of the course
3.88	3.07	your colleagues' opinion about the instructor
19.40	29.53	total %

Table 11. Comparison of common student perceived criteria for Q3 and Q4

Q3 (%)	Q4 (%)	Subjective common factors for Q3 and Q4
13.93	12.43	clarity and organization of the course
13.18	14.97	instructor can answer questions well
13.13	14.04	instructor's knowledge of the subject
5.71	3.07	class opinion
45.96	44.50	total %

Table 12. Comparison of common student perceived criteria for Q1 and Q3

Q1 (%)	Q3 (%)	Subjective common factors for Q3 and Q4
9.89	14.04	instructor's knowledge of the subject
4.37	13.03	instructor is available and helpful
5.63	12.43	clarity and organization of the course
3.88	3.07	your colleagues' opinion about the instructor
23.77	42.57	total %

Other remarks

The initial survey asked students to provide reasons they may use for assigning SET scores. The request was not for a complete list of factors influencing their decisions but rather for the ones they feel they use more often. In the follow-up survey, which involved a different group of students, most of them acknowledged the previous collection of criteria as their own by assigning various numerical weights to them. The highest agreement for student-used criteria is given in Table 13.

Table 13. Top student-perceived criteria for SET questions

“instructor's knowledge of the subject”
“student feels that he is learning as opposed to wasting time”
“course is interesting”
“the material taught was useful/relevant”
“student was able to learn”

The heaviest weight (about 20% for Q2) was assigned by students to the fact that the material taught was useful/relevant. It is also interesting that while almost all students favor courses which are interesting, the relative importance of this feature for SET scores is relatively low (about 10% for Q2).

Trigger factors

The survey also included a question that asked for reasons that might trigger students to assign high scores or low scores irrespective of other criteria normally used. Student opinion in showed in Table 14 and Table 15.

Table 13. Student perceived triggers for higher SET scores included:

professor truly cares how students do in the class
personal experience
course was easy, much easier than expected
if it interests me
I might feel more involved than usual
ability to sit in class and absorb material with relatively low amount of note taking
easy going atmosphere; ability to freely ask questions
my grade
overall content was great; a lot of materials were covered
instructor tries to make sure everyone learns the material
a good meal in the morning
if I feel like going to class helps me learn and the tests challenge my knowledge
practicality of content
when the teacher can answer my question quickly and says it in a way that I can understand
lectures are progress not waste of time

Table 14. Student perceived triggers for lower SET scores included:

professor obviously has other things he'd do rather than teaching
if I feel I am not learning or applying the course, then it is a waste and irrelevant to my learning
personal experience
if teacher is unfair or inconsistent with his grading techniques
if the course has nothing to do with my major
if the material was pertinent but I had only to memorize rather than learn
grading techniques
overwhelming difficulty of tests
organization: it's a real downer
unwillingness to give alternate explanation of concepts
that subject is unimportant or expected in every class
if I am bored with material
if the instructor used time poorly on a regular basis
fast course pace; not able to sufficiently understand material in given amount of lecture time
instructor is illegible
the less I understand or use the content
experience and other people's opinion
if the content did not reflect test
if the material is useful but downplayed by the instructor
if I feel the whole class leaves every day under 'what did we learn?'
if instructor cancels class and not in office during the office hours
instructor not available for outside help
if I feel like the teacher hates teaching the class
second guessing leads to loss of confidence in instructor
instructor can't answer student questions
my grade is not the best
when the teacher makes no sense
lectures are not progress but waste of time

Some reasons mentioned by students are directly linked to the quality of instruction. However, some may be very subjective. As students consider that reasons as the ones listed above can override their normal course evaluation questionnaire, the SET scores may not always reflect the quality of instruction provided.

4. Conclusions

We investigated the students' perspective on some fundamental questions based on previously identified factors employed by students in SET feedback. Our previous work was a preliminary stage for the present work, which confirms, refines, and adds new insights into students' perception of effective teaching. The questions used in the survey are general. However, the answers came from electrical engineering students reflecting their perceived educational needs so that the analysis is unlikely to generally extend to the arts field.

Our analysis shows that the most influential factors perceived by the student population in their responses to SET questions are "instructor's knowledge of the subject", "clarity and organization of the course", "instructor can answer questions well", "the material taught was useful/relevant". The criteria are well aligned with the scope of the SET questionnaire to assess the quality of instruction provided. However, the overall weight of this most influential student-perceived criterion accounts only for 32% of the assigned weight for all four questions (Q1 to Q4) examined. This may allow significant room for other subjective factors, less relevant to the quality of education, to occasionally play an inadvertent role. In support of such a possibility comes the fact that students did identify many more subjective reasons that may trigger them to assign high or low scores to SET questions independent of the criteria regularly employed. We found that grades can influence SET scores, supporting to a certain extent the conclusions of others [3, 6]. However, the weight of this student-perceived factor is, at least for our group, rather modest.

The results of the study are limited by the size of the student population surveyed. Nevertheless, the results of the study appear consistent and complementary and are likely of interest to other engineering educators. The student selected factors were confirmed by a different engineering student body and a more quantitative hierarchy of student criteria could be established. In their quest for higher student ratings, new faculty could start from the factors identified in this study and from their relative importance and could attempt to gauge their own class preferences by running a calibration survey at the beginning of the course. As shown in our work, student perception relative to good teaching is usually different from the instructor's understanding of the same concept and daring to probe this perception may be rewarding. The survey could be less direct than the one used in our study, essentially asking students about their perceived educational value of the most influential factors identified here (for instance, on a scale from 0 to 10). The authors believe that the results of this pilot study could be replicated and refined on a larger scale for more general confirmation of the present conclusions.

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