The Tulane University Biomedical Assessment Instrument: Preliminary Validity and Reliability Data

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Introduction

At present, there are no statistically validated and commonly used assessment instruments designed to evaluate the specialized content and student learning required in biomedical engineering (BMEN) courses. Accordingly, rigorous assessment and comparison of BMEN courses and student achievement is of nationwide concern. Additionally, as the number of BMEN programs grows, and more programs seek accreditation, the need for BMEN-specific course/learning assessment tools will also increase.

As part of our collaborative efforts to implement and assess active learning experiences throughout the BMEN curriculum, we have developed a questionnaire – the Tulane University Biomedical Assessment instrument, or TUBA – which examines student perceptions of BMEN course objectives, procedures and outcomes. A number of the questionnaire's items address the BMEN-specific program outcomes required by ABET. The TUBA model also contains questions which assess affective and kinesthetic educational objectives, by focusing on teamwork issues, teaching style, students' belief in their own abilities and desire to continue their education, peer interactions, and laboratory projects. While student perceptions are only one part of a comprehensive assessment program, they are certainly important. By addressing student perceptions of core outcomes and fundamental pedagogical issues, TUBA should be relevant to a range of BMEN programs which offer a wide variety of specialized "tracks," different areas of programmatic emphasis, *etc.* Given that there exists a need for a measure such as the TUBA, the following sections will describe the development and subsequent validation and reliability testing that has been thus far performed.

Development of the TUBA

In keeping with the tenets of Industrial/Organizational Psychological assessment instrument construction, the TUBA measure was developed in a series of steps. First, a group of subject matter experts (SMEs), consisting of BMEN faculty at Tulane University as well as test development SMEs from Tulane's psychology department were selected to participate in the measure's development. Next, the BMEN SMEs were queried as to the focus of the measure. Following numerous meetings and discussions, it was determined that a multi faceted assessment measure was called for. A list of questions/items was generated which would best account for the most salient of information that was desired concerning the BMEN students. Next, the list of items was organized into a series of constructs or categories that best identified the type of information that these items were hoping to discover. After consulting with BMEN SMEs to ensure the constructs accurately represented the information sought, as well as to ensure the items were appropriately placed in each assigned construct, the TUBA instrument was generated. Again, the TUBA, now complete with construct labels, was delivered back to the SMEs so that they could review the items and ensure their proper wording and placement. After implementing suggested changes, the TUBA became complete (See Figure I).

Figure I

Student Rating of
BME "Bridge" Course

For each of the following questions in the blank write the number corresponding to your opinion about the course. **1. strongly disagree** **2. disagree** **3. neutral or undecided** **4. agree** **5. strongly agree**

MY PERCEPTION OF WHAT HAPPENED IN THE COURSE

1. This course included a number of "hands-on" projects or exercises._____
2. In this course I frequently worked on projects or exercises with a partner or in a small group of students _____
3. A variety of formats (for example, lecture, demonstration, small group problem solving, discussion of "homework" problems) were used in this class_____
4. This class required more work than do my other courses_____
5. The objectives for the course were clearly presented_____
6. The course included learning experiences closely related to the course objectives_____
7. The course included training in how to work effectively with other people in a group_____
8. Everyone participated in class discussion_____

<u>The following questions have to do with laboratory or "laboratory-like" experiences</u>:

9. The laboratory projects seem related to the course objectives_____
10. The laboratory projects were carried out with one or more lab partners_____
11. [Answer only if lab projects were carried out with partners] The projects were such that each partners' work was fairly equal_____
12. The sequence of laboratory projects was thoughtfully planned so that later projects built on knowledge and skills developed in earlier projects_____
13. Laboratory projects were coordinated well with what was being covered in the class_____

14. The laboratory projects were well prepared (e.g., instructions were clear, needed materials and equipment were at hand, sufficient time was available)_____

HOW MY SKILLS AND ABILITIES WERE ENHANCED IN THIS COURSE

15. This course enhanced my understanding of principles and facts to which I was exposed in previous courses_____
16. In this course I increased my ability to apply principles from basic engineering to the types of problems encountered by biomedical engineers_____
17. This course has helped me be a more effective problem-solver_____
18. Through this course I have grown in my ability to integrate physiological and engineering information in solving biomedical engineering problems_____
19. In this course I have gained skill in applying quantitative techniques in solving BME problems_____
20. This course has helped me make better judgments about the quality of research published in BME journals_____
21. Experiences in this course have enhanced my skill in working in teams or small groups_____
22. In this course I was forced to adopt new perspectives in viewing BME problems_____
23. This course increased my understanding of physiology and biology_____
24. Through this course I've increased my ability to apply math, science, and engineering in solving problems at the interface of engineering and biology_____
25. In this course I've progressed in ability to make measures on and interpret data from living systems_____
26. As a result of this course I've improved my ability to address problems associated with the interaction between living and non-living materials and systems_____
27. This course increased my interest in conducting research or working in the domain of biomedical education that was emphasized in this course_______
28. My experience in this course has helped my identify myself clearly as a biomedical engineer (as opposed to a general engineering student)_____
29. This course has improved my ability to make measurements from living systems______
30. This course has improved my ability to interpret measurements from living systems_____

MY ASSESSMENT OF THE COURSE

31. Experiences in this course prodded me to think "outside the box" (more creatively)_____
32. This course provided a good transition for me from basic engineering courses to the independent project of my senior year_____
33. In this course I got better acquainted with other students than is usually the case in my other classes_____

34. What I learned from the course was more in depth than in my other courses_____
35. This course increased my confidence in my ability to successfully complete an independent senior research project_____
36. This course improved my ability to communicate verbally_____
37. I learned useful information in this course_____
38. This course has helped me in applying basic engineering principles and facts to solving “real world” BME problems_____
39. This course achieved its stated objectives._____
40. I was absent from this course less than I have been from my other courses_____
41. I looked forward to going to this class and/or lab._____

THE INSTRUCTOR

42. The course instructor responded clearly and thoroughly to questions asked in class_____
43. The instructor seemed sincerely interested in knowing whether or not students understood course material._____
44. The instructor was effective in leading group discussion_____
45. The course instructor was knowledgeable about the content of the course_____
46. The instructor quickly learned students’ names_____
47. The instructor developed an understanding of individual students’ strengths and weaknesses_____
48. The instructor was resourceful in turning an unexpected happening in class or lab into a learning experience_____
49. The instructor was interested in the process through which students went in arriving at a solution to a problem_____
50. The instructor was an effective “coach” to individuals and groups engaged in problem solving_____
51. The instructor made an accurate and fair assessment of my success in the course_____
52. The instructor provided useful and timely feedback about my in-class participation_____
53. The instructor was effective in demonstrating and explaining effective ways to approach a complex problem._____

As can be seen in figure I, the TUBA was developed to represent three primary constructs; student perceptions of what happened in the course, skill and ability enhancement as a result of the course, and a general assessment of the course. Additionally, since not all BMEN courses have laboratory components, the first section concerning student perceptions of what happened in the course has a subcomponent of laboratory experiences that is broken out and assessed as an independent factor.

Validation and reliability assessment of the TUBA

As the TUBA is a multifaceted measure, representing at least three distinct constructs, the first step in validation of the TUBA was confirmatory factor analysis. Factor analysis is a tool by which one can determine the underlying factor structure of a given group of items, allowing us to determine that each proposed construct is accurately and productively represented by the items which make up the factor. Separate analyses were performed on the Spring versus Fall 2001 data sets, enabling us to better ensure that variance explained in the assessments results are not due to chance combinations of individual differences within the sample. Of course, further analysis with students from differing BMEN programs would further improve the TUBA's validation confidence. The Spring 2001 administration consisted of 134 BMEN students, and the Fall 2001 administration consisted of 113 students. Since the courses surveyed consisted primarily of third year BMEN undergraduate students, and the administration was Spring followed by Fall, it is likely that very few of the students surveyed in the Spring participated in the Fall survey administration. Accordingly, it can be assumed that the two administrations were composed of essentially independent samples of students.

Results of both the Spring and Fall administrations of the TUBA suggest that the *a priori* factor structures predicted during the construction of the TUBA are supported. Analysis of each of the four identified constructs and sub-factors resulted in single factor solutions, supporting the stability of each dimension or factor structure.

Since factor analysis supports the validity of the measure, in that the TUBA seems to be measuring what it was intended to measure, the next step in the assessment process is to explore the reliability of the measure. While one facet of reliability is supported by the second administration of the TUBA passing the same validation process as the first administration, validity can be further assessed through a measure of internal consistency called coefficient alpha. Coefficient alpha is a representation of the mean of all possible split halves of any particular measure. For example, in a split half analysis, if a construct contains eight items, then the test would be split in half and each half would be correlated with the other. Coefficient alpha is essentially the mean of every possible split half, and so represents the most accurate possible assessment of a tests internal consistency. While factor analysis will result in an estimate of alpha, a more useful method of measuring alpha is through item analysis. Item analysis allows us to further examine the structural cohesion of the individual factors. Through item analyses, it is possible to determine the extent to which each item aids or detracts from the overall structure of a given measure. Accordingly, as the structure of a measure becomes more consistent, the reliability of the measure strengthens. An example of how item analysis was used in the assessment and subsequent modification of the TUBA is as follows: The first construct measured via the TUBA was student perceptions of what happened in the course. Factor analysis indicated that there is a single factor represented by the eight questions presented on the TUBA. However, further examination of the results of the factor analysis suggests that one item, item 4 ("This class required more work than do my other courses") did not seem to be associated with the other seven items of the sub-scale (especially on the Spring distribution of the TUBA). Accordingly, (see table I) the reliability, as indicated by Alpha, indicates a relatively low reliability for the Spring distribution concerning the construct in question. While the Fall distribution and the combination of the two distributions are adequately high, there is still cause to explore further. The results of subsequent item analysis indicate that if item 4 were deleted from the construct “My perception of what happened in the course”, the reliability of the scale increases from alpha = .763 to alpha = .843. Likewise, if item 4 were to be deleted from the Fall TUBA results, alpha increases from alpha = .864 to alpha = .870, with the total of the two administrations increasing from alpha = .813 to alpha = .851. Obviously, in this situation, reliability is substantially enhanced by the removal of this item.

Table I

Construct measured	Alpha		
	Spring	**Fall**	**Total**
My perception of what happened in the course:	0.763	0.864	0.813
Laboratory or "Laboratory like experiences":	0.884	0.879	0.880
How my skills and abilities were enhanced in this course:	0.940	0.925	0.932
My assessment of the course:	0.967	0.950	0.960

After considering the factor analyses and item analyses of the TUBA, only a few minor changes are indicated. First, item 4 should be either modified to properly measure the first construct, or it should be dropped. Similarly, but much less strongly indicated, items 34 and 40 may be slightly rewritten to further enhance their addressing the construct “My assessment of the course”. In the case of item 34 (What I learned from the course was more in depth than in my other courses) and item 40 (I was absent from this course less than I have been from my other courses), much as with item 4 (this class required more work than do my other courses), the items have in common a comparison of this course with other courses. It seems that such comparisons are stimulating the students to respond in a dissimilar way from the other items within each respective construct. In the case of item 4, a comparison is necessary, and so the item will be dropped. However, in the case of items 34 and 40, the comparative component of the items will be dropped, resulting in “The material learned in the course was very in depth” and “I was absent from this course only rarely”.

Conclusions

The TUBA measure has been demonstrated to be both valid and reliable for measuring several important constructs within the realm of BMEN courses. Not only does it promise to provide an effective means of evaluating many important issues in BMEN course perceptions, but since these are student perceptions of issues strongly related to ABET criteria, the TUBA may well demonstrate itself to be a valuable tool in determining whether BMEN programs are meeting many of the ABET criteria necessary for continued accreditation.

The next step of validation of the TUBA will be two fold. First, we will continue to use it to assess the BMEN students at Tulane University, providing further longitudinal data. Second, the TUBA will be tested on samples form geographically disparate BMEN programs to ensure it generalized well to programs other than Tulane’s.

Bibliography

1. Cascio, Wayne F., Costing Human Resources: The Financial Impact of Behavior in Organizations, third edition, South-Western College Publishing, United States, 2000.
2. Guion, Robert M., Assessment, Measurement, and Prediction for Personnel Decisions, Lawrence Erlbaum Associates, Publishers, Mahwah NJ, 1998.
3. Myers, Jerome L. and Well, Arnold D, Research Design & Statistical Analysis, Lawrence Erlbaum Associates, Publishers, Hillsdale NJ, 1995.
4. Pedhazur, Elazar J. and Schmelkin, Liora P. Measurement, Design, and Analysis: an Integrated Approach, Lawrence Erlbaum Associates, Publishers, Hillsdale NJ, 1991.
5. Tabachnick, Barbara G. and Fidell, Linda S. Using Multivariate Statistics, third edition, Harper Collins College Publishers, New York NY, 1996.

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