A TRANSPORTATION ENGINEERING BODY OF KNOWLEDGE FOR UNDERGRADUATE CIVIL ENGINEERS

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1. INTRODUCTION

During the course of their careers, every civil engineer will almost certainly be required to deal with some aspects of transportation engineering, regardless of whether they choose to focus in that discipline or not. In order to better prepare undergraduates at Valparaiso University to face this challenge, the author has assembled a collection of knowledge in the transportation area that all civil engineering students should possess upon entering the work force.

This body of knowledge was assembled from surveys of civil engineers in numerous fields, civil engineering faculty members, and civil engineering students. These groups were surveyed to determine the relative importance they placed on various aspects of transportation engineering.

After an initial introduction of the reasons for the study, the study itself and the results of that study will be discussed. Following the discussion of the study, a review of student perceptions of the same series of topics will be compared to the study findings.

2. REASON FOR THE STUDY

The majority of civil engineers will deal with transportation related issues at some point in their careers. The purpose of this study was to establish the knowledge about the field of transportation that an engineer with a Bachelors degree in civil engineering should possess at the time they enter the work force. This knowledge can be divided into categories: that which all civil engineers should know about transportation and that which those going into the field of transportation should possess. This information will then be used to design a series of required and elective transportation classes to help better prepare the students to face the transportation-related issues they will encounter in their careers.

3. THE STUDY

The study consisted of surveys completed by civil engineering faculty members and civil engineers in numerous concentrations, including transportation, who were alumni of Valparaiso University. These groups were surveyed to determine the relative importance they placed on various aspects of transportation engineering, both for students who will be working in the transportation area and those who will be concentrating in some other area of civil engineering. Additionally, civil engineering students at Valparaiso University were surveyed to determine their perceptions of the relative value of each topic.

Surveys were completed by six faculty members who teach classes in the transportation area at either Purdue University in West Lafayette, Indiana or at Valparaiso University. This contingent is referred to henceforth as the "faculty". Additionally, the survey was transmitted to approximately 225 Valparaiso University civil engineering alumni. Fifty responses were received, of whom 26 listed their primary area of expertise as transportation, and 24 reported it as another area of civil engineering, such as environmental or structural engineering. These two groups are referred to as the "transportation alumni" and the "non-transportation alumni", respectively.

In addition to these groups, 70 civil engineering students (16 seniors, 25 juniors, and 29 sophomores) were surveyed to determine their perceptions of the importance of the various topics. This data was then compared with that from the other groups.

The survey listed 21 topics related to transportation engineering. After providing background data related to their work, each survey respondent ranked the importance they placed on each of these topics on a scale of 1 to 5, with 1 being completely unnecessary, 3 being to some extent necessary and 5 being absolutely necessary. Each respondent performed this evaluation twice, once for an engineer with a Bachelors degree in civil engineering entering the work force in the area of transportation, and then once more for an engineer with a bachelors degree in civil engineering entering the work force in an area of civil engineering other than transportation.

The 21 topics evaluated were:

- Airports
- CAD
- Drainage
- Earthwork
- Engineering economics
- Environmental Impact Statements
- Highway capacity/Level of Service
- Horizontal and vertical curve design
- Intersection design
- Mass transit
- Noise impacts
- Pavement design
- Safety
- Signal timing
- Specialized design software
- Surveying
- Traffic flow models
- Transportation system evaluation
- Transportation system planning
- Transportation system sustainability
- Trip generation studies

4. THE RESULTS OF THE STUDY

The body of knowledge is divided into two segments. The first is the knowledge about transportation engineering that all students should possess upon entering the work force. This material will be included in the sophomore-level, required, introductory transportation class. The second segment will be the additional knowledge required by those students who desire to pursue further study or a career in the area of transportation engineering. This material will be included in one or more upper-level elective courses.

For students going into transportation engineering, Figure 1 shows the comparison between the ratings provided by the faculty, the transportation alumni and the non-transportation alumni. As can be seen in the figure, the faculty placed more importance on 15 of the 21 topics than did either of the alumni groups. These topics tended to be the traditional transportation topics, such as highway capacity/level of service and the topics related to transportation design and evaluation. Typically, the transportation alumni ranked these topics higher than did the non-transportation alumni.

For students not going into transportation engineering Figure 2, shows the comparison between the ratings provided by the faculty, the transportation alumni and the non-transportation alumni. The results were somewhat lower than those for the students going into transportation, the major difference being that the ratings given by the transportation and non-transportation alumni were closer in this case. Typically, the transportation alumni ranked these topics higher than did the non-transportation alumni.

The results of the survey were then weighted and the two cases were combined to form a single ranking system for use in ordering the topics. This process consisted of the following steps:

- The ratings from the three respondent groups for the students going into transportation were combined, using a weighted average. Both the faculty and the non-transportation alumni scores were multiplied by 1.7, while the scores from the transportation alumni were multiplied by 2.5. (Initially, students were included and given a weighting factor of 1.0. It was later decided not to include them.) The values of 1.7 and 2.5 were based initially, on judgment and were later confirmed using a sensitivity analysis. The combined score for each topic was then normalized by dividing it by 5.9, the sum of the weights. This resulted in each topic being given a score between 0 and 1, which was then multiplied by 100%.

- The process was then repeated for the ratings for the students not going into transportation. The weights were adjusted by assigning the faculty and the transportation alumni a factor of 1.7 and the non-transportation alumni a factor of 2.5. The resulting scores where then summed and normalized for each topic.

- Finally the scores were combined for the students going into the transportation field being weighted at 60% and those not going into other fields being weighted at 40%. This was done to reflect the greater importance of the topics to the students entering the transportation field. These results are provided in Figure 3.

Once the topics were ranked, they were divided into those taught in other classes, those to be taught in the required course, those to be taught in the elective course, and those not to be taught at all. This decision was based in part on the premise that the information most needed by those not entering the transportation field should be in the required class – the only class they are likely to take.

Surveying and CAD are currently taught in Valparaiso University's freshmen surveying course, CE 151 Construction Surveying. Similarly, engineering economics are taught in a junior-level,

general engineering course, GE 301 Principles of Engineering Practice. These topics will be briefly reviewed as necessary during the transportation course sequence.

Based on their importance to civil engineers not entering the transportation field, the following topics will be assigned to the introductory transportation elective:

- Highway Capacity/Level of Service
- Horizontal and Vertical Curve Design
- Drainage
- Earthwork
- Safety
- Intersection Design
- Pavement Design
- Mass Transit
- Environmental Impact Statements

Most of these topics are currently taught in the introduction to transportation engineering course.

Based on their importance to civil engineers entering the transportation field, the following topics will be assigned to the transportation elective:

- Transportation System Evaluation
- Transportation System Planning
- Transportation System Sustainability
- Signal Timing
- Traffic Flow Modeling
- Trip Generation Studies
- Noise Impacts

None of these topics are currently taught in the introduction to transportation engineering course.

Neither airport design nor specialized computer programs will be covered in the course sequence. The topic of airports was eliminated as it received the lowest scores from each of the three groups surveyed. Specialized computer programs will not be included for two reasons. First, they would require that a lab time be included in order to effectively teach them. This would require a reduction in lecture time. Secondly, one can never be sure as to what software students will be using when they enter practice.

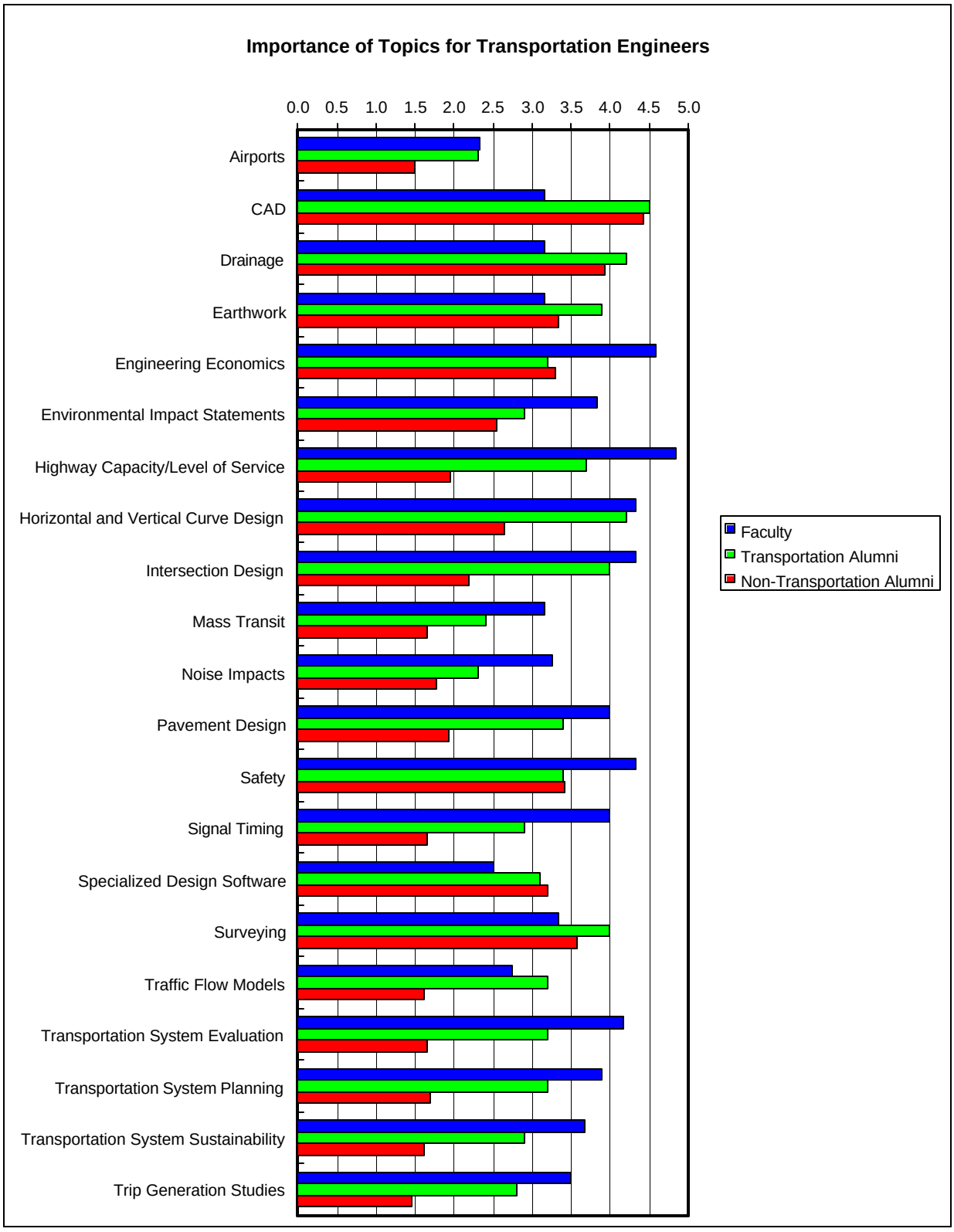

Figure 1: Rankings of topic importance for students entering the transportation field

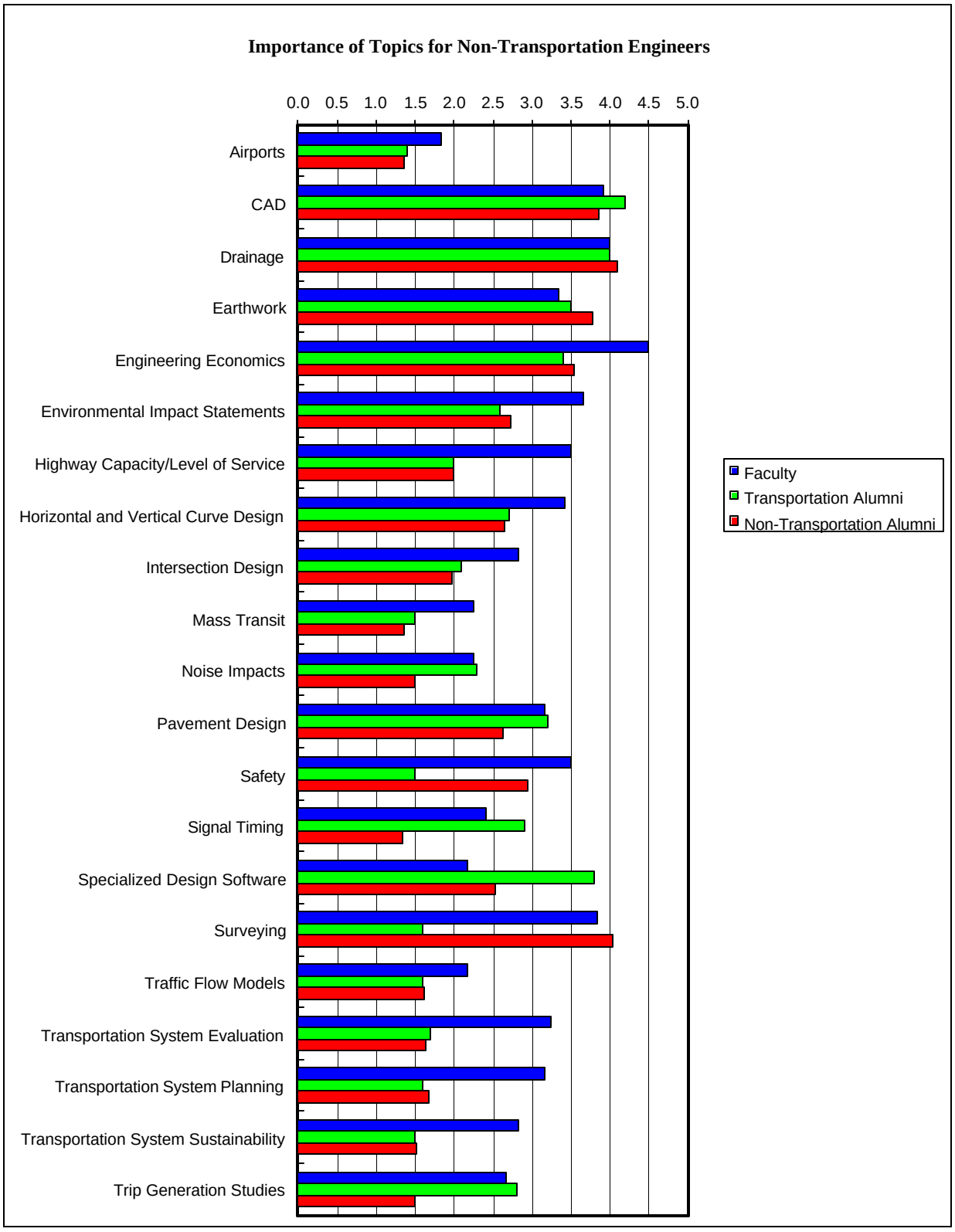

Figure 2: Rankings of topic importance for students not entering the transportation field

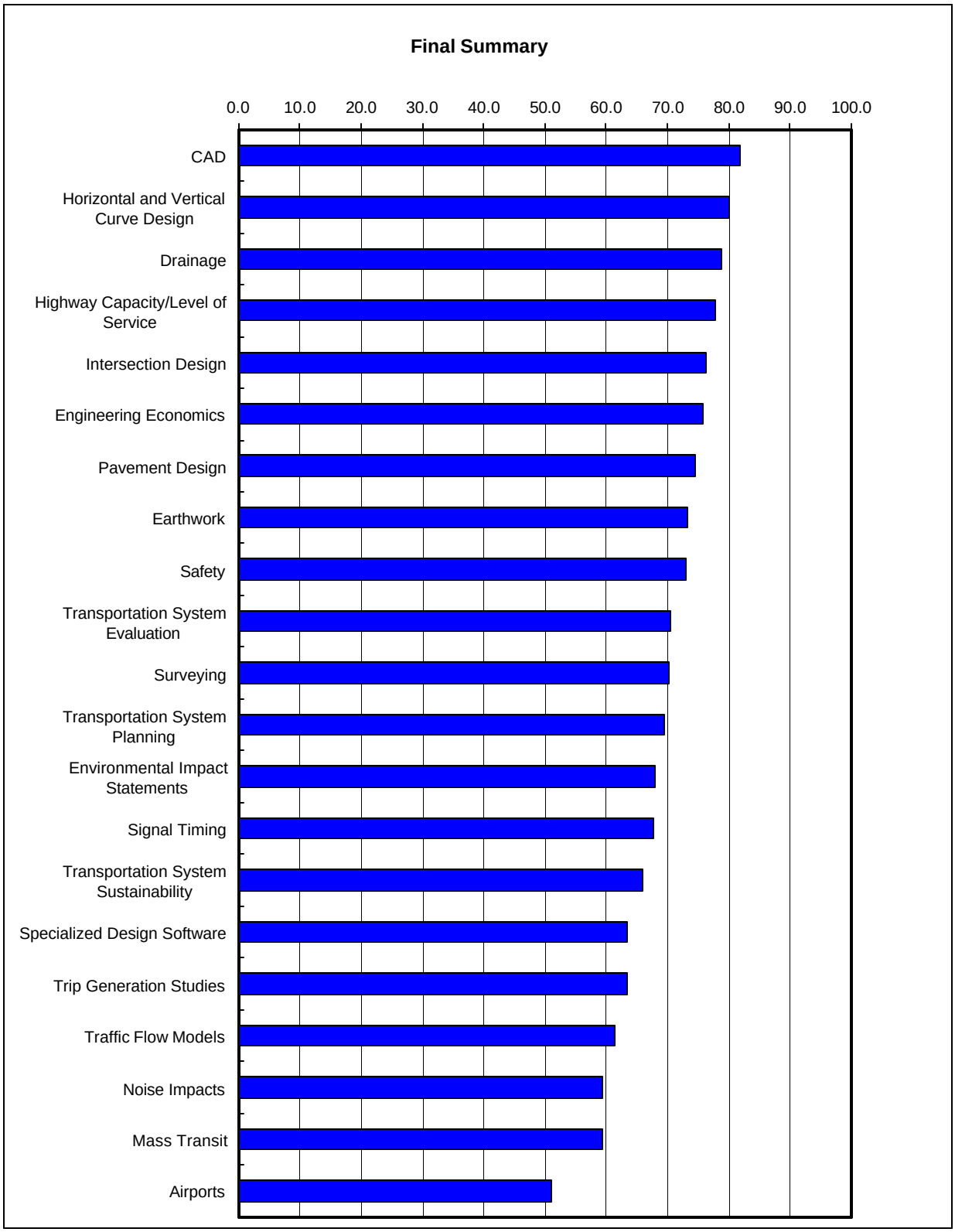

Figure 3: Final topic importance weighted scores

5. STUDENT PERCEPTIONS

In addition to the data obtained from faculty members and practicing engineers, civil engineering students at Valparaiso University were surveyed to determine how their perceptions compared with those of the faculty and alumni. All of the students had either completed or were taking the introductory transportation class.

Gauging student perceptions was deemed important because, when selecting the material for the course sequence, the differences between what professionals and students thought important was made obvious. For example, students ranked airports much higher than any of the other surveyed contingents did. By knowing the students' predisposition, one can better work to convince them that the material covered in the courses is really the most important material on the topics. The confidence that the material covered in the course is applicable to the work that they will perform during their careers will serve to motivate the students in their studies of the material, resulting in a more satisfactory experience for both the professor and the students.

For students going into transportation engineering, Figure 4 shows the comparison between the ratings provided by the students and the alumni and faculty. As can be seen in the figure, the students placed more importance on 19 of the 21 topics the faculty and alumni. The exceptions were engineering economics and surveying.

For students not going into transportation engineering, Figure 5 shows the comparison between the ratings provided by the students and the alumni and faculty. As can be seen in the figure, the students again placed more importance on 19 of the 21 topics than did the faculty and alumni. In this case, the exceptions were engineering economics and drainage. Of the 19 that the students gave a higher rating, the largest differentials occurred in the topics of mass transit, transportation system sustainability, transportation system planning, and traffic flow models. These four topics were the same (although ordered slightly differently) as for those students going into transportation engineering.

6. CONCLUSIONS

Based upon surveys of faculty members who teach transportation courses, and working civil engineers both in and out of the transportation field, a transportation-related body of knowledge was established for all civil engineering students. This knowledge was then divided into the topics necessary for all civil engineers and the knowledge important only to those pursuing a career in the transformation field.

The body of knowledge is being used to establish a two-course series consisting of one required and one elective course. Additionally, initial student perceptions of the potential course topics were reviewed in order to help understand the importance of the material covered in the courses.

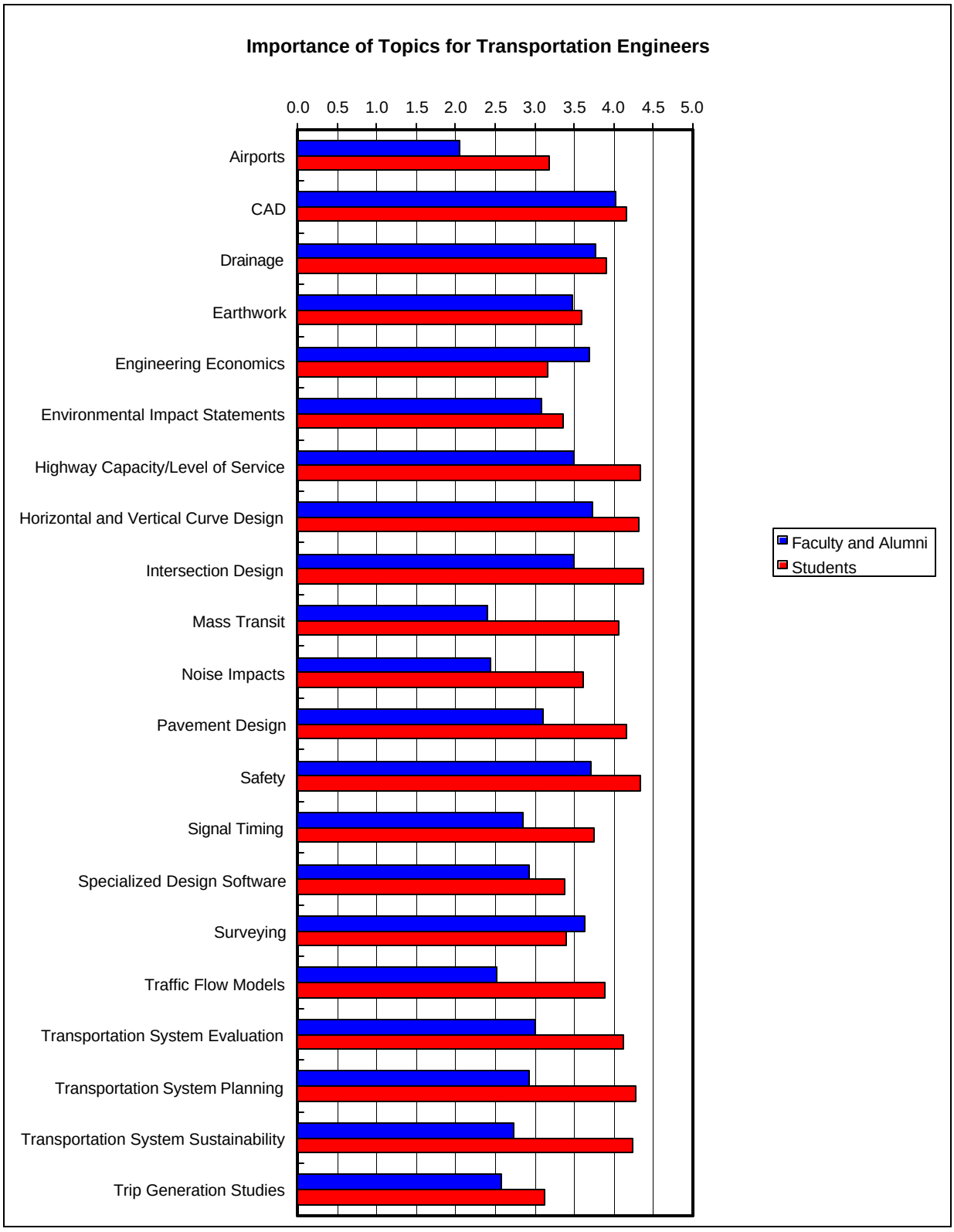

Figure 5: Student and faculty rankings of topic importance for students entering the transportation field

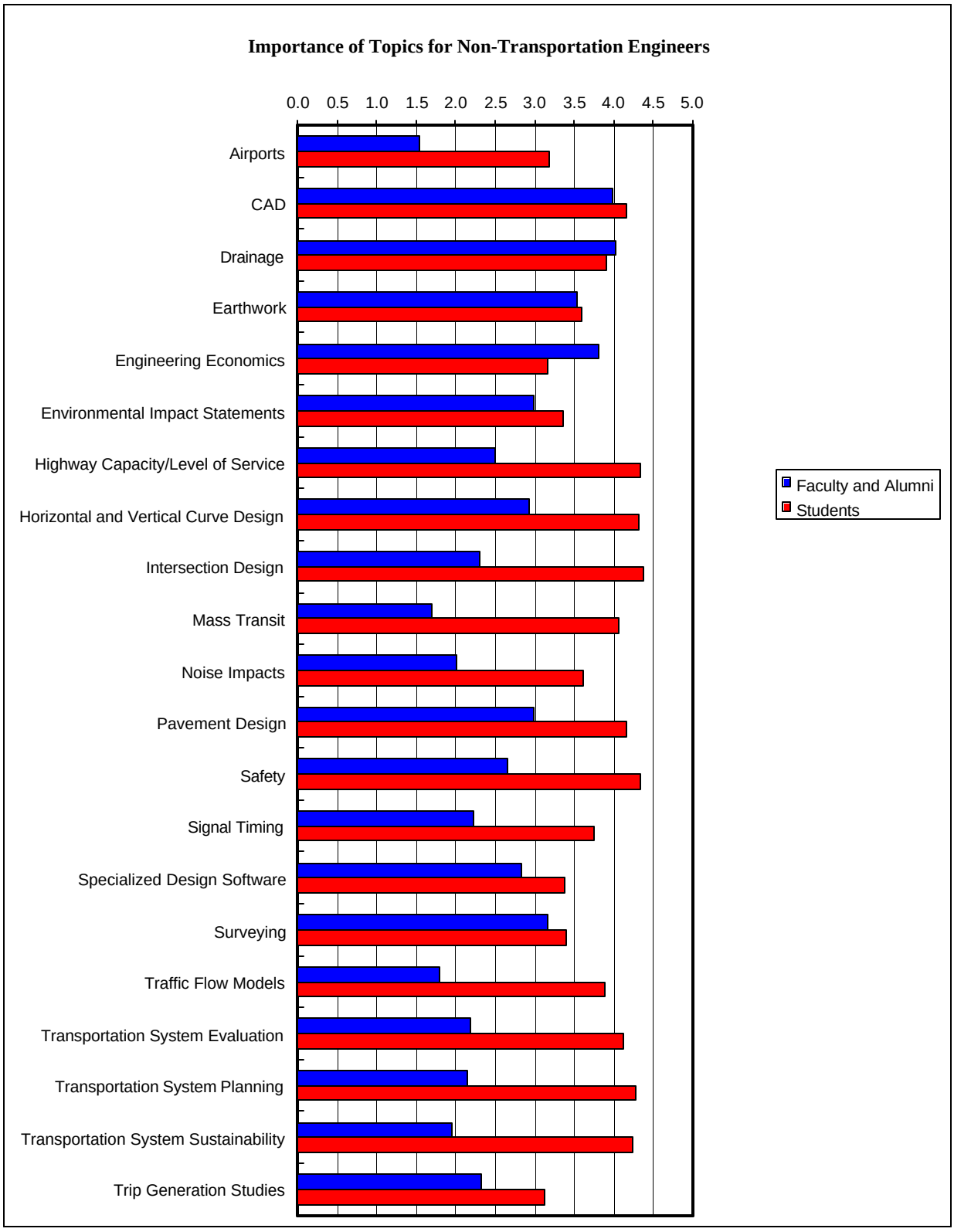

Figure 6: Student and faculty rankings of topic importance for students not entering the transportation field