Research Needs Statements for Project Topic Selection: A Pilot Study in an Undergraduate Civil Engineering Transportation Course

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Introduction

Design projects are an integral part of undergraduate engineering education in the United States. When topic selection for senior projects, capstone design courses, or term projects is placed in the hands of the students, they can find it puzzling, even overwhelming. While it is recognized that topic selection presents a great challenge for college students[1, 2], limited research exists on the subject, especially as it pertains to undergraduate studies[2, 3]. The ease of students' access to information, via web search engines and open-access specialized web tools, is tremendously helpful for topic identification. Such a wealth of information allows students to gather a list of ideas for project topics, but the perceived risk associated with selecting only one of the ideas can be overwhelming because students may be unsure whether a particular topic would be suitable for the class or might cause them to fail in later stages of the project (e.g., the topic is more difficult to tackle than they anticipated).

In light of these concerns, the following question emerges: Are there any web tools that can help students identify a topic that is not only of interest to them but also worth pursuing? For the transportation engineering field, the answer is yes. The Transportation Research Board (TRB), a program unit of the National Academies of Sciences, Engineering, and Medicine, has built and maintains an extensive research needs statements (RNS) database. TRB committees, researchers, and practitioners annually identify research topics of interest in the field. This database has been built with experienced researchers in mind and is a means by which topics of interest and value to the community can be identified for funding. The RNS are reviewed and approved by at least one sponsoring standing committee. In addition, the statements are reviewed by the TRB staff representative responsible for the primary sponsoring committee, as well as indexing staff. Furthermore, the statements are reconfirmed at least once annually or removed from the database. This ensures that the statements are not outdated.

As stated on the TRB website:

> An important function of the Transportation Research Board (TRB) is to stimulate research that addresses concerns, issues, or problems facing the transportation community. In support of this function, TRB Technical Activities standing committees identify, develop, and disseminate research need statements (RNS) for use by practitioners, researchers, and others. The RNS on this website have been developed by the technical committees.[4]

To the authors' knowledge, no other field maintains such an extensive research needs database that reflects the current, high-priority research needs in the field. Nevertheless, similar databases and other resources exist in many science and engineering fields. For example, there are various conference paper repositories and field-specific journals that provide similar information about where research interests and needs lie in a particular field. At the same time, more general resources exist that document broader research needs, such as the National Academy of

Engineering Grand Challenges[5]. Field-specific databases can be explored for use in field-specific introductory courses, while more general databases and resources (such as grand challenges databases) can be explored for discipline-based introductory courses (see for example Riley[6] and Corneal[7]).

The RNS database has been used as a tool to aid topic identification and selection for graduate-level research. Nevertheless, there has been no systematic documentation of such use by graduate students and/or professors. Furthermore, to the best of the authors' knowledge, the database has never been used directly before as an educational tool at the undergraduate level. Typically, for term projects in introductory transportation classes, students select their topic based solely on their interests, or alternatively, the instructor assigns specific topics.

The goal of this paper is to identify opportunities to improve instruction around the use of the RNS database as a means to identify and select a course project topic in transportation engineering. To achieve this goal, this paper uses data collected in an elective undergraduate civil engineering course.

This paper builds on a previous study in which the authors focused solely on an empirical analysis of students' responses to a survey distributed at the end of the term[8]. Specifically, the authors[8] completed a descriptive quantitative analysis of the quantitative data collected from the survey and a thematic qualitative analysis of the feedback provided by the students through the open-ended questions included in the survey. The goal of the study was to explore whether the RNS database is beneficial for use in undergraduate transportation coursework as part of a term design project.

The findings of the study suggested that the students perceived the RNS database to be a useful tool for project topic identification and selection. Nevertheless, a few challenges faced by the students in their efforts to utilize this tool were identified. Most students felt that the database and the website were easy to use and articulated a number of benefits to using the database for the course's purposes. Among other benefits, students felt that the RNS provided them with useful information that guided their later work on the chosen topic, helped them generate initial ideas and narrow them down to fit the project scope, introduced them to terminology specific to their topic of interest, and helped them understand why the specific topic is relevant and, generally, better grasp the underlying concepts involved. Most students recommended the future use of the database for similar class projects, which suggests a preference over other traditional topic identification and selection methods typically used in undergraduate-level engineering courses. Based on these findings, the authors[8] provided a number of recommendations for instructors who might consider using the RNS database for educational purposes, as well as for TRB staff tasked with maintaining the database.

This paper builds on the prior study by looking at connections between students' use of the RNS database to select their group project topic and develop their proposal and their experience with the RNS database. The prior study only focused on the students' self-report use and experience with the RNS database, not on the students' and groups' topic interests, topic selection, or proposal.

To achieve the research goal, this paper addresses the overarching research question of what is the interplay among the students' and the group's topics of interest, the RNS selected, the proposal developed, and students' individual experiences with the RNS database. Findings are used to make recommendations more generally about using field-specific and/or more general resources in an undergraduate engineering course to guide selection of a project topic.

Methods

This paper presents the results of a pilot study aiming to explore the explicit use of the RNS database for educational purposes, specifically undergraduate project topic selection. Data were collected in the Spring 2016 offering of CE361-Introduction to Transportation Engineering, an undergraduate-level design elective course offered every semester at Purdue University. The students used the RNS database for the term design project, as described in the section *Term Project Description*.

Class Composition

The class enrolled 47 students, most of whom were majoring in civil engineering. In terms of gender, 81% of the students were male (38 students) and 19% female (9 students). Although this course is recommended as a technical elective in the students' junior year, students often decide to take it in their senior year. This was the case in this semester; 34 of the students were seniors (around 72% of the class), with 10 having declared candidacy to graduate that semester.

Term Project Description

Students had the freedom to undertake any type of study (site-specific study, case study, synthesis, design project, planning-related project, etc.) with a focus on any transportation-related problem of their choice. The main learning goal of the term project was to provide students with the opportunity to work towards solving real-world problems of interest to them. By encouraging such problem-solving, the project aimed to foster the students' critical thinking. The project further aimed to provide students with a more comprehensive perspective on the topics covered during the semester. The project accounted for a total of 20% of the students' final grade, with the final submission accounting for 10% and two intermediate submissions each accounting for 5%.

The first intermediate submission (herein referred to as Intermediate Project Submission 1 [IPS1]) involved the development of a proposal for the project. For this stage, students were grouped by the instructor into five large groups of nine or ten students based on their interests and time availability, as indicated by the students in Survey 1 (see the *Data Collection* section for more information), and their education level. The instructor also attempted to evenly distribute the junior students in each of the five groups. For this submission, students were instructed to explore the RNS database[4], select a needs statement according to the group's interests, thoroughly review the needs statement selected, and formulate their own problem statement and details. The instructor noted that the group's project would likely be narrower in scope than the needs statement and that some objectives of the needs statement would be very difficult to achieve within the course of a semester. In addition, students were instructed to divide the project into tasks and assign group members to each task based on the difficulty and

workload of each task and the group members' interests and backgrounds. Each group member was to be assigned to only one of the tasks. The proposal was to capture this process and, at a minimum, describe

- the problem statement, project goals, and objectives;
- the tasks and the reasoning behind the specific task division; and
- a tentative timeline.

The proposal was graded using a rubric that evaluated the performance of the students on five aspects: a clear explanation of the motivation/connection with the selected RNS; clearly stated, well-supported, and appropriate goals/objectives; an adequate description of the proposed data collection/methodology; a feasible project management plan (i.e., appropriate groups for future tasks and well-designed timeline); and appropriate and proper citation of additional sources used in the proposal. The RNS database was used primarily in this stage of the project.

The second intermediate and final submissions were completed by groups of one to five students that resulted from the division of tasks described above. The second intermediate submission included an outline of the final report and a brief presentation of the group's progress to the instructor. The final report presented the complete work on the specific tasks the students undertook. This report was due at the end of the semester and was required to be 10 to 15 pages long.

More information pertaining to the term project is provided in the authors' prior study[8].

Project and Group Introductions

One class session was devoted to introducing and describing the term project. During this session, the student groups were announced and the groups met for the first time. After the instructor described the project, the groups got acquainted and completed a small assignment (herein referred to as Group Introduction Assignment [GIA]). Specifically, the groups had to exchange their contact information, decide on a name for the group, have an open discussion pertaining to potential broad topics of interest and list a few of interest to the group, and decide on a communication and work model (how the students in each group planned to work together, coordinate their communications, etc.). The instructor suggested that the students identify a few broad topics during the session because she believed it would make the search through the RNS database easier for the students, especially considering the size of the groups and how cumbersome the communication across so many students might be. However, it was recommended (but not mandatory) that the groups finalize their topic upon consulting the database and identifying a RNS.

Data Collection

Table 1 provides an overview of the data collection methods used and the corresponding research questions (discussed in the *Data Analysis* section).

Survey 1. In the first week of the class, students individually responded to a series of questions that allowed the instructor to get to know her students. Of particular interest to this work is a question asking students what topics they were interested in learning about in the class. This

question, together with two additional questions that asked students to (1) rank a number of transportation-related topics in order of interest and (2) indicate their time availability, were also used as guides to place students in large groups.

Survey 2. This was the primary data collection instrument. The survey was distributed during the last week of classes, and students were given credit as part of the quizzes/in-class activities grade for completing it. Essentially, all students were expected to participate in this survey as part of normal course activities.

The survey was completed online and was not anonymous. While the lack of anonymity may distort student responses, if for instance, students did not feel free to express their opinions or altered their opinions to please the instructor, it was necessary so that the students' responses could be linked to other data sources. The survey instrument collected information pertaining to the following:

- The utilization of the database. Specifically, two questions were included that asked whether the student used the RNS database personally and whether the student read the needs statement selected. Possible answers were *yes, no, not sure*.

- The experience of the students in using the database. Specifically, six questions were included that aimed to solicit information pertaining to the students' perceptions of the ease of use of, usefulness of, and experience with the RNS database and selection of their needs statement. A four-point Likert scale (from *strongly disagree* to *strongly agree*) was used for these questions, with the addition of a fifth *no opinion* option at the end. In addition, five open-ended questions were included that asked students to provide their feedback on several relevant topics and justify their responses to the six questions mentioned above. At the end of the survey, there was also space where a student could leave any additional comments on the use of the RNS database.

Student work on the GIA and the first intermediate submission of the project (i.e., the proposal) was also part of the data collection. Finally, the selected RNS were reviewed and their quality was assessed. Many of the RNS included in the database are overall well developed; they provide a clear scope, study objectives, a literature review, and other resources. Nevertheless, the authors of the RNS are not required to provide a well-developed statement. Therefore, the database includes several RNS that provide more limited information.

Data Analysis

This paper addresses the overarching research question through the description of three group cases of significance (see Table 2). Three cases of significance were selected to improve the robustness of the findings compared to a single-case analysis[9]. The cases are initially developed and reported herein with the guidance of a series of case development questions presented in Table 1 and using the data sources indicated.

Table 1. Case development questions and data sources

Case Description	Case Development Questions	Data Sources
Interests in Transportation	1. What are the students' topics of interest?	Survey 1
	2. What are the group's topics of interest?	GIA
RNS Selection	3. What is the nature of the RNS selected?	IPS1, RNS database
	4. How does the RNS topic relate to the interests of the students and the group?	IPS1, Survey 1, GIA
Group Project Proposal	5. What is the nature of the group's project proposal?	IPS1
	6. How does the project proposal relate to the RNS selected?	IPS1
	7. How does the project proposal relate to the interests of the students and group?	IPS1, Survey 1, GIA

Next, a cross-case synthesis looks across the three cases to compare and contrast the results from the case description components, using a simple qualitative comparison (for more information on commonly used cross-case synthesis method the reader is referred to Yin[9]). The cross-case synthesis is a point for point comparison of the group finding for the case development questions 4, 6, and 7 (Table 1) as well as a comparison of the groups' perceptions of using the RNS database to select a needs statement and prepare a project proposal from Survey 2.

Results

Group Cases

The three selected cases of significance are described in detail below and summarized in Table 2. These cases are unique based on students' areas of interest, the quality of the RNS statement selected, and the quality of the group proposal. Specifically, the significance of the CE361 Mass Transportation case lies in the group's overall performance on IPS1. In addition, this group selected a very laconic needs statement, and a relatively large fraction of the students in this group would not recommend the use of the database in future courses. The case of Group 1 - Movement is unique in the class because the group committed to a very specific topic of interest before they had a chance to consult the RNS database. In addition, the group selected a relatively brief needs statement that did not provide references or additional material, the group had more seniors than any other group, and relatively more students in this group than in other groups would recommend the use of the database in a future course. Finally, the significance of the PDOT case lies in this group's selection of a very well-developed needs statement. In addition, the group did not report any potential topics to be explored for its project in the GIA, which implies to the authors that the group probably decided on their topic upon searching through the database.

Figure 1 presents the composition of each group in terms of the students' education levels.

Table 2. Summary of cases of significance

Case	RNS Database Utilization	Students' Interests Indicated in GIA	Quality of RNS Statement Selected	Quality of Group Proposal
CE361 Mass Transportation	Group Size: 9 Survey 2 Respondents: 9 Read the RNS statement: 9 RNS Users: 7	Multiple diverse areas	Brief with no citations	Well developed No citations
Group 1 - Movement	Group Size: 9 Survey 2 Respondents: 8 Read the RNS statement: 6 RNS Users: 5	New Urbanism	Brief with no citations	Incoherent Not well connected with the needs statement
PDOT	Group Size: 10 Survey 2 Respondents: 10 Read the RNS statement: 9 RNS Users: 9	Unstated	Well developed, providing abundant information and resources	Strong citations

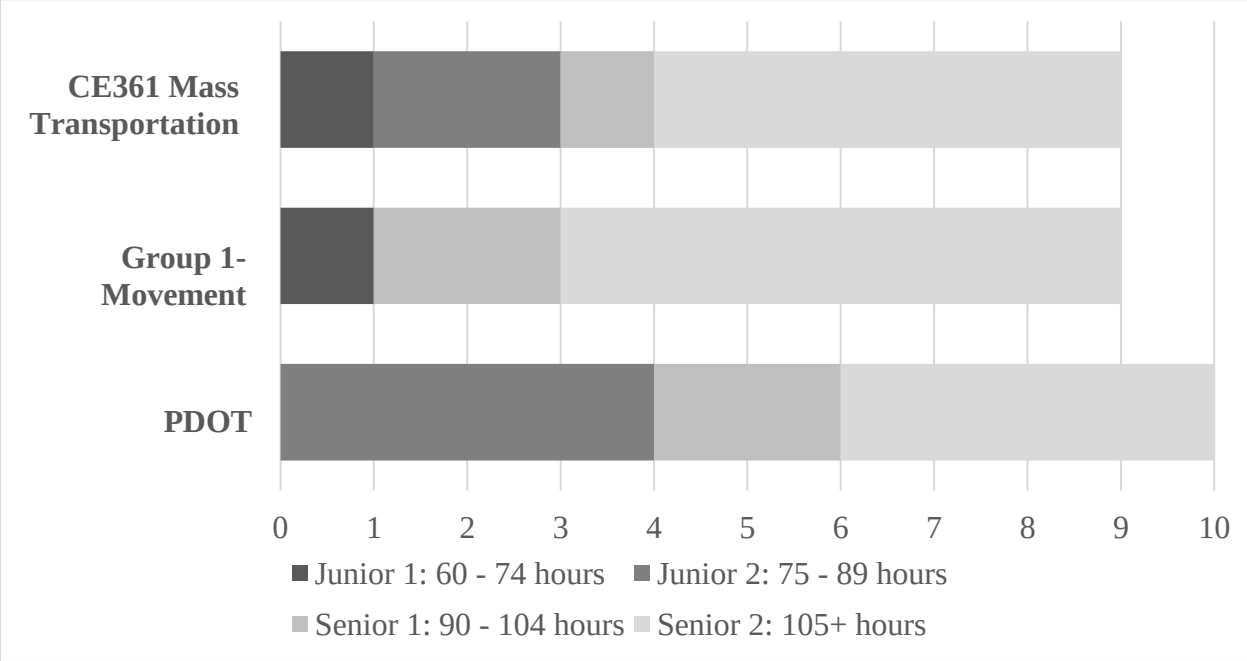

Figure 1: Group composition based on credit hours completed

CE361 Mass Transportation Group

Group Composition: This group had nine members distributed across various educational levels, (Figure 1). All but one were Civil and Environmental Engineering students; the remaining student was a Construction Management student. Two of the students were female, and the rest were male.

Interests in Transportation: The initial transportation-related interests of the students in this group, as identified from Survey 1, involved a mix of topics related to mass and air transportation. For example, some of the students' comments in Survey 1 were as follows:

- "[I want to learn h]ow to best design public transportation and utilize air and public transportation to improve the infrastructure of the US."
- "I would like to learn more about the design of transportation systems beyond just roads and highways, but also air, freight, etc."
- "I would really like to learn more about mass and air transportation."
- "I want to learn […] what makes public transportation systems most efficient."
- "[I want to learn about d]ata crunching for mass transport research."

During the initial class meeting session, group (minus one absent student) saw the following as potential research areas of interest: aviation, airport design, high-speed rail, subways, and mass transportation. It appears that this group had a broad array of interests, though all were related to mass transportation modes. They named their group *CE361 Mass Transportation Group*, which reflects their interests.

RNS Selection: The needs statement the group selected was titled "Community and Social Value of Airports" and was last modified in 2009[10]. The sponsoring committee of this statement is AV020, Aviation System Planning. Based on the authors' experience, this is one of the least developed needs statements in the database. The statement includes only the following text in its main body:

> Airports have a social value as well as contributing to the financial value of a community. How far does that extend? Is it a legitimate cost of government? GA airports are not parks for the rich, they contribute to life. [10]

The needs statement does not provide any resources or any other information.

The statement appears to align with some, but not all (i.e., high-speed rail, subways, and mass transportation) of the stated interests of the group members as well as with the initial ideas the group recorded in the GIA.

Group Project Proposal: This group received the highest score among the groups on IPS1. The group scored excellently in four of the five aspects evaluated during the grading. The proposal of this group was overall well structured and easy to read and comprehend. The students clearly presented the study goals and objectives. Furthermore, the group presented an exceptional project management plan; they had a well-considered task breakdown based on thematic units (Figure 2) and a detailed timeline. The one aspect that the instructor perceived as lacking was the use of additional resources and the proper documentation of such resources.

The group proposed a project to explore the impacts of the construction or expansion of an airport as a means to assess the community and social value of an airport. They suggested two broad categories of impacts: impacts to the economy (either personal or business) and impacts to social life (at the individual or community level).

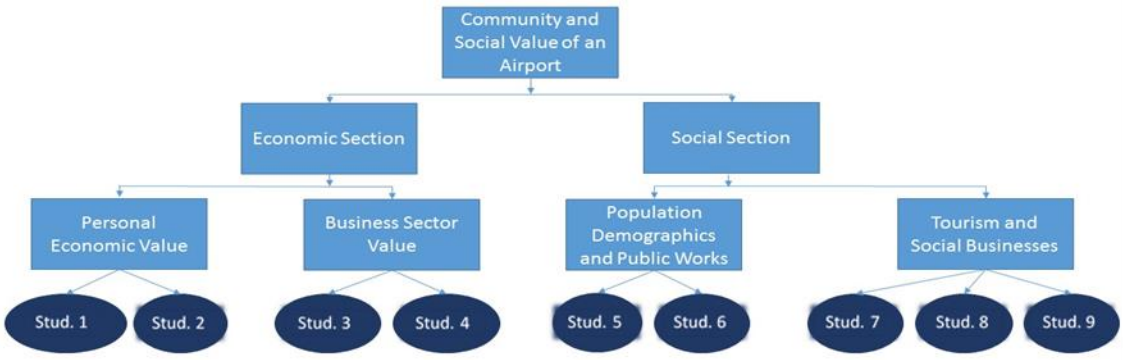

Figure 2: Unique elements of students' work

It was noteworthy that the group managed to link its proposal with the selected needs statement very well. It appears that the title of the needs statement was used as the core idea, and the rest of the proposal was built around this idea. The impact categories also seem to correspond to the needs statement sentence "[a]irports have a social value as well as contributing to the financial value of a community."

Because the topic of the statement and the proposal are so closely related, it appears that the project proposal is in alignment with the students' and group's interests (though, again, only with some of the group members' interests).

Overview: The group had a good distribution of students at various educational levels. Through the brainstorming session the group identified a number of broad potential topics of interest (as captured in the GIA), though the group did not seem to come to a conclusion or commit to any specific one. Those topics seemed to be related to the interests of the individuals, as captured in Survey 1. The group later selected a statement related to some of those interests. The statement, however, did not seem to cover any of the other interests that the group members indicated. The selected statement was very brief and did not provide any references or other resources. Notwithstanding its briefness, the students seemed to have used the statement directly for the formulation of the proposal's problem statement and for the task division. The proposal that the group submitted was very good overall, though it was lacking in terms of the resources used and the proper documentation of such resources.

<u>Group 1 - The Movement</u>

Group Composition: This group had nine members and relatively more seniors than the other groups (Figure 1). All but two members were Civil and Environmental Engineering students; of the remaining two, one was a Construction Management student and one was a Mechanical Engineering student. Four of the students were female and the rest were male.

Interests in Transportation: The initial transportation-related interests of the students of this group, as identified from Survey 1, mostly involved topics related to transportation planning and sustainability. For example, some of the relevant students' comments in Survey 1 were as follows:

- "[I want to learn about t]he various aspects of transportation planning."
- "I want to learn about current sustainable transportation systems, and what is being done in transportation that will help or is hurting our environment."
- "[I want to learn about s]ustainable transportation and highway transportation."
- "I want to learn about challenges in sustainable transportation projects."
- "[I want to learn more about t]he current technologies and methods used to best deal with [t]he population and transportation needs of our society."

In the initial class meeting session, all group members appeared to have had a thorough discussion of their interests, as is evident from the very detailed list of potential topics that they handed in to the instructor (as part of the GIA). They mentioned that they are interested in New Urbanism and a number of alternative transportation modes, as seen in Figure 3.

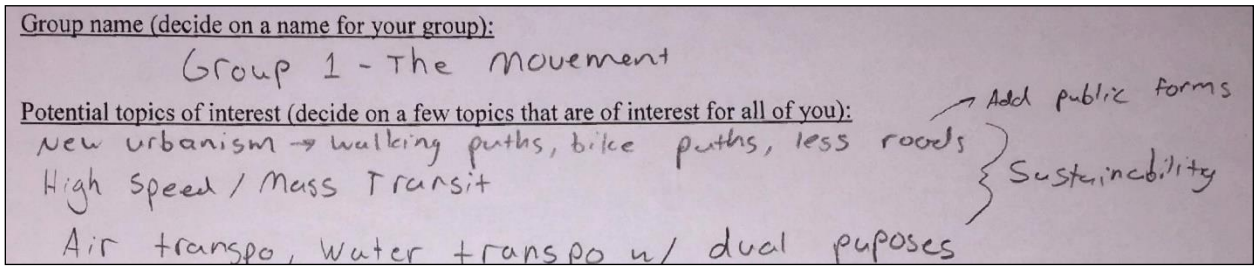

Figure 3: Part of the GIA showing the group's topics of interest

The students named their group *Group 1 - The Movement.* From Figure 3, as well as the group name the students selected, it might be inferred that the students attempted to find a more holistic topic that combines several research areas (such as alternative transportation modes and sustainability) and approach it from a planning perspective (e.g., the group mentions "less roads" and "add public forms," which indicates to the authors that the interests of the group were mainly related to planning and not design, operations, etc.).

RNS Selection: The needs statement the group selected is titled "Best Practices on TDM [Transportation Demand Management] Applications in Regional Long-Range Plans, Land Use Plans/Smart Growth"[11] and was last modified in 2007. The sponsoring committee is ABE50, Transportation Demand Management. It is not a well-developed needs statement; it only includes a brief description of the perceived research need and of the research objectives (approximately 100 words in total).

The statement highlights the need for research on the topic of transportation demand management (TDM) strategies related to the concepts of smart growth and sustainable development. The specific statement does not have a very clearly defined focus. Although the statement mentions concepts such as sustainability and smart growth as trends in planning practices "that strive to integrate trip reduction strategies into a comprehensive vision of regional community mobility and accessibility,"[11] it does not focus on these topics. The part of the

statement that is most closely related to the interests of the group proposes that these trends in planning practices are one of the key reasons why many communities are incorporating TDM applications in local planning processes. The statement proposes the need for research to identify strategies related to the concepts discussed above that are "compatible and complementary to long-range planning," to define the possible goals of such strategies, and to identify "planning techniques and tools" that can assist with the integration of such strategies into long-range and land use plans[11].

The statement appears to be somewhat related to the interests of the group members (as implied by the use of specific keywords such as transportation planning, smart growth, sustainability). However, the focus on demand management strategies does not seem to be related to any of the stated interests of the group members.

Group Project Proposal: The group received the median grade on IPS1. They performed well in three of the five aspects evaluated. Overall, the proposal was well written and the group provided sufficient background information on the topic. The students' ambitious plan was to design a model city that follows the principles of New Urbanism (or, as they put it, an "urban design movement" promoting "environmentally friendly habits" through a variety of means). The two aspects that needed substantially more work were the use and proper documentation of additional resources and the description of the proposed data collection and methodology.

The group proposed to form six subgroups (four of which had just one student) focusing on different "aspects of the city." After a few introductory paragraphs in the proposal, the group described each one of these aspects by partitioning the proposal into different sections, each of which focused on one concept. The final product, however, was not very coherent. The quality and level of detail of each section was not uniform, and there were no transitions between sections. In addition, there was no overview to explain how the different concepts fit together or contribute to the bigger picture. Based on the proposal and the proposed task breakdown, it can be inferred that the group was not very coherent.

In addition, even though the project motivation provided by the group was overall well developed, the connection between the needs statement and the proposal was not strong. The students attempted to connect their proposal with the needs statement by suggesting that "TDM applications will be researched and implemented into the city design." However, most of the sections discussing the different aspects that would be considered did not explicitly explore any TDM strategies, applications, or measures.

Overview: This group had relatively more seniors than the other groups in the class. The brainstorming session focused on the overarching theme of New Urbanism and many aspects of transportation related to this topic. The group's interests as a whole seemed to align with the students' individual interests (or an amalgamation of these). The significance of this case lies in the fact that the group members identified a very specific topic to pursue during the first brainstorming session and then attempted to locate a needs statement that fit with their topic. The interests of the group, however, did not seem to match very closely with the needs statement selected. The statement they selected was relatively brief and did not provide any references or other resources. The proposal the group submitted was relatively well written, though it was lacking in terms of the use and proper documentation of additional resources and the description

of the proposed data collection and methodology. In addition, the connection between the needs statement and the proposal was not strong. Finally, the proposal seemed incoherent.

PDOT

Group Composition: This group had 10 members with relatively more juniors than other groups (Figure 1). All but one of the group members were Civil and Environmental Engineering students, and the remaining student was in Construction Management. All 10 students were male.

Interests in Transportation: The initial transportation-related interests of the students in this group, as identified from Survey 1, involved a broad array of topics related to highway and pavement design. For example, some of the students' comments in Survey 1 were as follows:

- "[I want to learn the t]heories of highway design."
- "I would love to learn about pavement design and the reasoning for different types of pavement."
- "I would be interested to learn how to properly design a roadway while keeping in mind sight distances, proposed speed limits, and other factors."
- "I want to learn how to analyze and make decisions for highway design."

Despite the instructor's suggestions, the group decided, during the initial class meeting session, not to get into a thorough discussion pertaining to their interests during the class session and did not provide any potential topics of interest (under the section the students wrote "T.B.D."). They named their group *Purdue Department of Transportation (PDOT).* The name fits the lack of commitment to a specific topic demonstrated in the GIA.

RNS Selection: The needs statement selected was titled "Use of Recycled and By-Product Material in Soil-Structures"[12] and was last modified in 2015. Although included in the TRB RNS database, this statement seemed to focus on a topic that was outside of the scope of this class, or at least not immediately relevant; the statement advocated for the development of guidelines for the "use of recycled and by-product fill in soil-structure applications and [the] promot[ion of] the use of these materials." Based on the needs statement, the guidelines should, among other goals,

- provide recommendations for selecting appropriate recycled materials, identify suitable characteristics for such materials (including environmental suitability), and develop a list of suitable, high-potential recycled materials;
- explain the benefits of each recycled material (environmental, social, and economic); and
- design laboratory and field testing requirements and installation guidelines. [12]

Despite the fact that the statement did not appear to be closely related to the class focus, the instructor did not recommend a change because no instructions had been given at the beginning of the class pertaining to the specific topic selected and because the initial intention was to not guide the groups to select a specific topic. The instructor did, however, attempt to guide the students towards topics and/or methods discussed in class in the later stages of the work (for the second intermediate and final submissions). Ultimately, the students did an adequate job of connecting this topic with the broad area of transportation in IPS1 and throughout their project.

The needs statement was well developed. The developers presented a description of the need, study objectives, and study benefits. The developers also referenced a number of related resources in the literature; they briefly discussed nine studies. The needs statement was on the order of 1,000 words (without the references, which included the nine studies mentioned plus three others). In addition, the developers described specific tasks to be completed, an implementation plan, and a couple of brief statements on the relevance of the potential study. The sponsoring committee is AFS40, Subsurface Soil-Structure Interaction.

The statement seems to be somewhat related to some of the students' interests as stated in Survey 1. However, it does not seem to be well aligned with their interests, as most students discussed highway and/or pavement design. On the other hand, because the group did not provide any potential topics of interest in the GIA, the authors cannot assess whether the focus of the needs statement aligns with the interests of the group.

Group Project Proposal: The group received the median grade in the first submission, scoring excellently in three of the five aspects evaluated. The proposal was coherent and easy to read and understand. The group provided several references used to support the group members' motivation. It is noted here that only this and another group (not discussed in this paper) out of the five groups in the class provided/cited additional references. It is revealing that the group treated the statement as a resource and referenced the needs statement itself. The two aspects that needed work were the description of the proposed data collection and methodology and the project management plan (i.e., subgroups for the tasks, a timeline, etc.).

The goals of the group as stated in IPS1 were to (1) assess the environmental impacts of using recycled materials in roadways, (2) assess the feasibility of different recycled materials for such use, and (3) conduct a benefit-cost analysis to assess the economic merits of using recycled materials. The proposal was well linked to the needs statement selected. It appears that the group selected a few of the recommendations included in the statement and focused on those. The students did a good job filtering out the parts of the needs statement that would be difficult for them to achieve given their time and resource constraints (such as the goal related to laboratory and field testing requirements and installation guidelines).

Because the topics of the needs statement and the proposal are so closely related, the proposal seems to be somewhat related to but not well aligned with some of the students' interests, as indicated by Survey 1. Because the group did not record any topics of interest during the first class meeting, however, the authors cannot assess the relationship to the group's interests as a whole.

Overview: The group had a relatively good distribution of students at various educational levels. The students did not indicate any potential broad topics of interest in the group session report, which implies to the authors either that they did not discuss any or that they had a number of topics and they were not particularly interested in any specific one. Based on the instructor's observations during that class session, the latter seems more probable given the discussion that the group had. The significance of this case lies in the fact that the group selected a well-developed statement that provided ample references and other resources. It cannot be assessed whether this statement was linked with the interests of the group as a whole, but it was loosely linked with some of the interests of the individual students. The proposal that the group

submitted was very good overall, though it was lacking in terms of the description of the proposed data collection and methodology and the project management plan. This was one of two groups in the class that received a perfect score in terms of properly cited and used resources. The proposal appears to be directly linked with the needs statement selected; the group seems to have used the statement as a resource for this submission.

Cross-Case Synthesis

The cross-case synthesis looks across the three significant cases described above to compare and contrast the results discussed in the previous section. Specifically, this analysis focuses on questions 4, 6, and 7 (Table 1) and also explores students' perceptions of the RNS database from the case development questions.

How does the needs statement topic relate to the interests of the students and the group? All three groups discussed herein selected RNS that focused on topics related to the students' individual interests in different ways. For CE361 Mass Transportation, the individual students' interests included a mix of topics, most of which were reflected in the broader topics identified by the group as a whole. However, the needs statement selected focused on a very specific topic and, therefore, was related to some of those interests more than others. For some students, the topic was perhaps not aligned with their personal interests. For Group 1 - The Movement, the group's interests appeared to be a combination of the students' interests. The group identified a very specific topic to pursue during the brainstorming class session. The needs statement selected was somewhat related to the topic that the group identified, but it was not a strong fit. Nevertheless, the students seemed to have partitioned their work in a way to align with their personal interests. For PDOT, the students' interests seemed to involve broader topic areas that were more loosely defined. The needs statement identified was, to some extent, related to those areas, though it was not a very close match to all areas. The group did not provide any information pertaining to the interests of the group as a whole, so inferences cannot be drawn for the relationship between the needs statement's focus and the group's interests.

How does the project proposal relate to the needs statement selected? All three groups submitted a proposal that was related to varying degrees to the needs statement selected. For CE361 Mass Transportation, the needs statement seemed closely related to the proposal, especially the proposal's problem statement and proposed division of tasks. For Group 1 - The Movement, the proposal was loosely related to the needs statement selected. Specifically, the proposal seemed to be linked with some of the secondary points raised in the needs statement. Finally, for PDOT the proposal seemed to be based on the needs statement directly.

How does the project proposal relate to the interests of the students and the group? All three groups prepared proposals related to the students' interests. For CE361 Mass Transportation, the proposal seemed to be related to the interests of some of the individuals and to some of the interests of the group as a whole. For Group 1 - The Movement, the proposal seemed to be directly linked with the interests of the group and somewhat related to the interests of most of its members. For PDOT, the proposal was somewhat related to the broader interests of the students, though it was not a close match. Again, inferences cannot be drawn regarding the relationship between the proposal and the group's interests because the group did not provide sufficient information about these.

What are the students' perceptions of using the RNS database to select a needs statement and prepare a project proposal? The degree to which each group found the database easy to use and/or useful and the degree to which they found the selected needs statement useful also varied, as did the recommendations for using this tool for similar projects in the future. Figure 4 presents the responses of the students per group for the following three questions (from Survey 2):

- I found the TRB RNS database easy to use and understandable.
- I found the TRB RNS database useful for this project.
- I would recommend using the TRB RNS database for similar projects in the future.

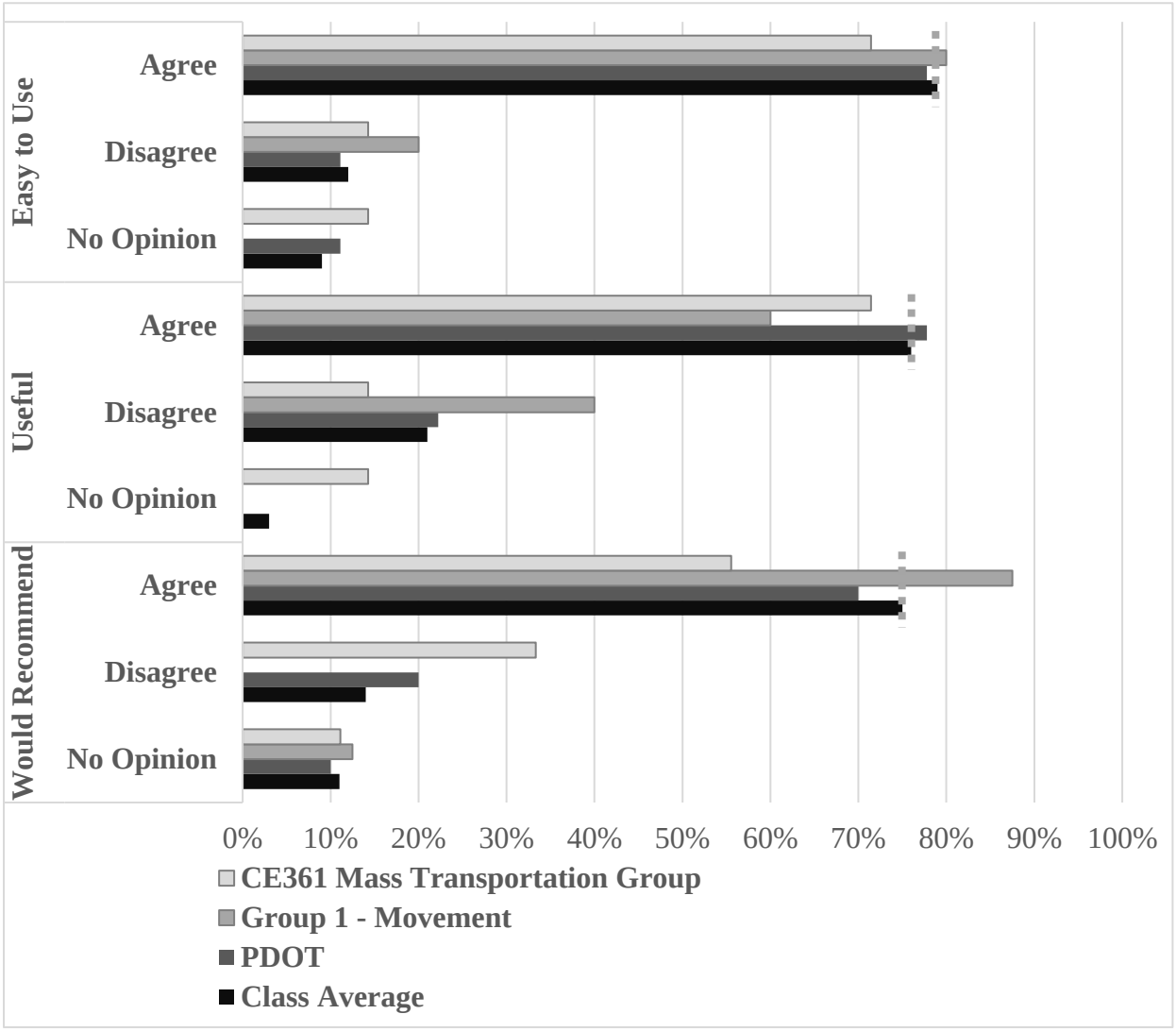

Figure 4: Groups' perceptions of the RNS database

In Figure 4, the percentages for the ease of use and usefulness are calculated based on the students who used the database and percentages for the recommendation are calculated as a total for the group. The three groups seemed to have used the RNS database in different ways, this may relate to the overall experiences of the groups being somewhat different from each other. Generally, all three groups found using the database relatively easy. As Figure 4 shows, of the

students who searched through the database, in the CE361 Mass Transportation group five out of seven (i.e., 71.4%) thought that the database was easy to use and useful (relatively less than the class average, i.e., 79%), in Group 1 - The Movement four out of five (i.e., 80%), and in PDOT seven out of nine (i.e., 77.8%).

Some of the commonly noted helpful features were the classifications the RNS database uses, the keywords, and the search function. In addition, Group 1 - The Movement and PDOT found the overall website organization and interface helpful. The groups provided different opinions regarding the issues that make the database difficult to use. For example, CE361 Mass Transportation and Group 1 - The Movement thought that the long needs statements that the database includes makes searching through the database cumbersome. In addition, CE361 Mass Transportation and PDOT felt that it was difficult to find a needs statement suitable for the class's term project. Group 1 - The Movement and PDOT had additional, sometimes contradictory concerns. For example, Group 1 - The Movement found that most statements were very specific, which they thought made the selection of one difficult, while PDOT mentioned that some of the statements were very broad, which made their selection of one difficult.

In terms of the usefulness, as Figure 4 shows, of the students who searched through the database, in the CE361 Mass Transportation group five out of seven (i.e., 71.4%) thought that the database was useful (relatively less than the class average, i.e., 76%), in Group 1 - The Movement three out of five (i.e., 60%; noticeably less than the class average), and in PDOT seven out of nine (i.e., 77.8%; relatively more than the class average).

The three groups seemed to have very different opinions on why searching through the database and using a specific needs statement were useful and very similar opinions on why they were not. These opinions were closely related to how each group approached the database and how they actually used the statements. CE361 Mass Transportation reported that the needs statement was useful for guiding the direction of their problem statement, providing a general understanding of the problem, and suggesting general ideas about the various aspects of the problem. Group 1 - The Movement mentioned that the needs statement was useful for formulating their problem statement and steering it towards a topic more closely related to transportation. In addition, the group found the database as a whole and the specific needs statement they selected to be a good resource for familiarizing themselves with terminology they could later use in their project. Finally, PDOT provided additional reasons why they found the database and the specific needs statement useful. The group thought that the information the needs statement included was useful and helped them write their proposal. In addition, they found the information provided in the database as a whole and the depth of many of the statements useful for their purposes, and they mentioned that searching through the database helped them brainstorm the topic they would like to pursue. On the other hand, students from all three groups mentioned that using the database restricted them in some ways. Only few students from CE361 Mass Transportation and PDOT felt this way, but those who did thought that using alternative methods to identify a topic for the term project (such as using a search engine or brainstorming) would be less restrictive. Group 1 - The Movement found the database difficult to use because they had already committed to a specific topic and could not easily find a matching needs statement.

As far as the overall opinion of the group as expressed through the members' recommendations for the future, CE361 Mass Transportation generally found the database easy to use and useful, but, compared to the class average, a higher percentage of the students who used the database in this group did not have an opinion or thought that the database was difficult to use and/or not useful. Most students in the group would recommend the database for future use, though the percentage was a noticeably smaller than the class average (five out of the nine students in the group, i.e., 55.6%, with a class average of 75%). Group 1 - The Movement thought that the database was easy to use; however, compared to the class average, a noticeably smaller percentage of the students who used the database found the database useful. Nevertheless, compared to the class average, a noticeably higher percentage of students in the group would recommend the use of this database in the future (seven of the eight students, i.e., 88%). For PDOT, the percentages of the students who used the database and found it easy to use and useful were approximately the same as the class averages. Nevertheless, compared to the class average, a smaller percentage of students in the group would recommend the database for future use (seven out of ten, i.e., 70%).

Authors' Reflection and Insights

Based on the students' perceptions and interests, the authors infer how the students might have used the RNS database. Specifically, to develop additional recommendations for the design of instruction on the use of the RNS database, the authors discuss the following questions:

How do students in groups that finalized their project's research area before searching through the RNS experience using the RNS database compared to those students in groups that selected a research area using the needs statements? (Order of Steps)

How does the length and quality of the selected statement as well as the information provided in the statement impact students' opinions of the RNS database and the quality of the students' work? (Quality of Statement)

<u>Order of Steps</u>

One relationship worth exploring is whether students in groups that finalized the research area for their project before searching through the RNS database had a different experience compared to students in groups that used the database to select a topic (i.e., whether or not the students started their search having some broad topics in mind). Among the five groups in the class, only Group 1 - The Movement did not follow the recommendation of the instructor to finalize the project topic upon consulting the database and identifying a RNS. Relatively more students from this group found the database not to be useful for the project they completed. Nevertheless, even though the database did not help this group identify their topic for the project directly, most of the students in this group found that searching through the database and selecting a specific statement helped them with their project in various ways.

This group likely attempted to find a statement that included the term New Urbanism. This would not have returned any results at the time of the search. If the students could not come up with another term to broaden the search, the students may could have been frustrated. Perhaps the group could have been guided by the instructor to expand its search and include terms that

were somewhat related to their topic of interest (such as "transit-oriented development"). This could have resulted in some additional needs statements, which in turn would probably have made the database more useful for this group.

This is confirmed in that some of the students felt that it would have been easier for them if they had not finalized the project idea first because the group had difficulty finding an appropriate statement. It is interesting, however, that relatively more students in this group who searched through the database thought that the database was easy to use. It should be noted that this group tasked relatively fewer students to searching through the database, which might be due to the fact that the topic was already decided (i.e., the students thought that fewer students would need to be involved in the task of finding a "matching" statement). Therefore, it is possible that the fact that relatively more students found the database easy to use was an artifact of self-selection (i.e., only students who were interested in searching through the database were tasked with doing so). Notwithstanding the students' experience with the database, however, it is noteworthy that all but one student in this group would recommend the future use of this database for similar projects in the future. The reason for this is unknown.

On the other end of the spectrum, PDOT presented no topics of interest resulting from the brainstorming class session, which might indicate that the students talked very generally about their interests and relied more on the database to select a topic. The group referred to a number of different ways that they thought that the database was useful, including helping them with brainstorming. Nevertheless, this was the only group that selected a well-developed needs statement, and thus, any patterns may have resulted from other factors than when they committed to a topic. At the same time, however, it is possible that the flexibility they had due to the initial lack of commitment allowed them to select a well-developed statement.

Generally, it seems that the sequence of searching through the database and identifying a specific topic of interest to pursue affects the way students experience the use of the database. Especially if the students first select a specific topic, the database as well as the specific resource they decide to use might be less useful to them than they otherwise would be.

Quality of Statement

The second and third relationships worth exploring are between, on the one hand, the length and quality of the selected statement and the information provided in the statement and, on the other hand, the students' opinions of the database and the quality of the students' work. In this pilot use of the database, even though students were advised to search for well-developed needs statements and were given an example of such a statement, all groups but one selected a very brief and underdeveloped needs statement. Specifically, the project instructions informed the students that a well-developed RNS provides a clear scope, study objectives, a literature review, etc., and suggested that the students try to find a well-developed needs statement. Nevertheless, apart from the project instructions, the instructor did not, in the end, require students to select a well-developed needs statement or fully explain the benefits of doing so. To the instructor's surprise, only one of the five groups formed (PDOT) selected a well-developed needs statement. In fact, some of the students in different groups commented that having long statements made searching the database cumbersome.

Because PDOT did not provide any information on the initial interests of the group, the authors cannot speculate on the selection process. However, it noteworthy that at the time of the project there were approximately 140 active statements related to pavements and 850 related to highways (i.e., topics related to the students' interests as indicated in Survey 1). The statement selected was marked as related to highways, geotechnology, and bridges and other structures.

Overall, the findings of this work suggest that the students in PDOT seemed to have similar experiences with the RNS database to students in the other groups. No significant differences in the students' responses emerged regarding how easy to use they found the database to be or whether they would recommend it for future use. Rather, differences existed regarding the extent to which they thought searching through the database and using the specific needs statement was useful to them.

In terms of the quality of the students' work, the proposal submitted by PDOT received a similar grade to most of the other groups' proposals, and the quality of their work was not noticeably better or worse. Nevertheless, this group seemed to have taken advantage of more references and other resources than most of the other groups.

Overall, it appears that the quantity and quality of information provided in the resource the students use impact the way the students utilize that resource. In the case of PDOT, the students seem to have used the needs statement as a source of information. As such, the selection of a rich resource has the potential to influence both the students' attitude towards the database and the quality of their work. However, no strong patterns emerged from this analysis.

Conclusions

This paper aims to identify opportunities to improve instruction around the use of the RNS database. The findings of this study can be used to guide the future use of the RNS database as a means to identify and select a course project topic in transportation engineering. The findings may also be used to guide the future use of other field-specific databases and resources that may share similar functionalities with the RNS database. The findings of this study suggest that when students commit to a specific topic before they have the chance to conduct a search, it appears that the resource are less useful to them. For future uses of this or similar databases, the authors recommend that the instructor advise students to hold a work session as a group and have an initial discussion of the topics of interest while at the same time exploring the available database. It may also be helpful if the students become familiar with and navigate the database before they are introduced to the term project.

Furthermore, the findings suggest that the quantity and quality of information provided in the selected resource (herein, the selected needs statement) has the potential to affect both the experience of the students with the database and the quality of the students' work products. Even though the quality of the selected resource directly impacts the way the students utilize the resource, and therefore how useful they find the resource to be, it is not clear whether this significantly impacts the students' overall experience. Furthermore, it is expected that different groups will benefit from different uses of the database. In this analysis for example, it was found that depending on how concrete and specific the interests of the individual students and the collective interests of the groups are, a longer and more well-developed needs statement might

not be easy to find or might not be a good fit because its topic and guidance may be deemed overly specific. In light of the above, the authors recommend that students be advised to take full advantage of the database and its resources and try to select resources that are well-developed and provide a lot of information. This guidance will encourage students to utilize the database as both a tool that can help them brainstorm and, if they need to, as a source of information on the topic they select. Nevertheless, the students should be given flexibility to decide for themselves how to use the database, because restricting them to selecting a well-developed resource might further narrow down their options and make it more difficult for them to find a topic that aligns with their interests.

Study Limitations and Future Directions

The findings of this study suggest that the individual interests of the students, the collective interests of the group, the topic of the needs statement, the quality of the needs statement, the topic of the proposal, and how the students ultimately use the database and the selected needs statement are interrelated. However, the data sources utilized in this study did not explicitly solicit information concerning potential interrelationships. Future studies should collect additional information to further explore some of the questions this study only touches upon. For example, future research should collect data on the specific ways the groups use the database and solicit information directly on whether the students' opinions of the database are affected by the breadth of the area of interest the group initially identified. In addition, future research should collect information on how easy or difficult the group found it to identify a needs statement that matched their interests. At the same time, future research should directly solicit information regarding whether the students' opinions are affected by the characteristics of the statement selected.

Based on the findings of this study, it is also recommended that future studies explore the extent to which the individual interests of the students are reflected in the collective interests of the group affects the individual students' experiences with the database. Along the same lines, it may be important to investigate whether the use of the database is easier in smaller sized groups (for example, of four to five students), where students' interests might be better aligned, and whether such groups might benefit more from the database.

Finally, studies can be conducted in other fields to explore the use of similar field-specific resources or other resources that may share similar functionalities with the RNS database for project topic identification and selection.

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