Learner Types: A Means to Expand the Definition of Diversity and to Redesign Ethics Modules

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Learner types a means to expand the definition of diversity and to redesign ethics modules: Work-in-progress

Introduction

Considerations of diversity in science, technology, engineering, and mathematics (STEM) fields are often based upon gender, race, and ethnicity. Thus, efforts to quantitatively assess, and subsequently increase, diversity in STEM fields are focused primarily on demographic categories. Myopic focus on demographic diversity may mask homogeneity in other respects among the students admitted into STEM fields. For example, there is evidence that individuals who are typically attracted, selected, and retained by engineering programs tend to express certain personality characteristics of Introversion, Intuition, Thinking, and Judging (INTJ) as defined by Myers-Briggs Type Indicator (MBTI) [1].

As STEM-based education programs, engineering in particular, prioritize an increase demographic diversity, student recruitment efforts pay less attention to personality and other forms of student identity and expression. This may contribute to the assumption that STEM students, while demographically diverse, are homogenous with respect to learning. This could occur unconsciously, or schools may regard learners in STEM fields as an inherently homogenous population with respect to shared preferences, values, and motivations. The presupposition that STEM students are comprised of largely homogenous learners further assumes that <u>all</u> STEM learners could be served equitably by traditional STEM education approaches.

These assumptions present two major problems. First, INTJ is the rarest of the sixteen combinations of personalities categorized with the Myers-Briggs test, with only 2.1% of Myers-Briggs test-takers in the United States scoring into the INTJ classification [2]. Second, STEM students who are more "extroverted" and express greater emotional intensity (i.e. E/F in Myers-Briggs terminology), as opposed to "introverted" and "judging" (I/J) might not be supported in learning through traditional lectures that demand passive listening, internal (non-spoken) processing, and review of historical ethics cases. By targeting INTJ learners, STEM fields are inadvertently filtering out the majority of learners and those who could contribute diverse insights and perspectives. Thus, recruitment efforts devoted solely toward demographic categories might be missing a key piece to the diversity puzzle.

For a campus to foster a diverse STEM learning community, there is a need to consider the multiplicity of learning styles, personality traits, and other forms of identity expression among its members; one or more of these may constitute an additional basis for discrimination beyond demographic characteristics, as shown by Felder and Brent [3]. However, few institutions include measures beyond demographic diversity in their recruitment efforts and rarely are instructors offered tools (or other support) to assess, understand, and take into account their students' different backgrounds, belief-structures and personality types.

In light of this, this exploratory work-in-progress aims to elucidate a broader range of pedagogically-relevant heterogeneity among STEM students. Based upon that new understanding, the ultimate goal is to strategically design variants of learning modules that facilitate STEM ethics learning for the diverse students in the classroom. This research draws upon 264 surveys and student-writing samples from students across four institutions, specifically Notre Dame, St. Mary's College, Xavier University-Louisiana, and University of Virginia. The aim of this initial research is to explore the heterogeneity of students in STEM classrooms, while demonstrating that STEM students can be described more holistically when personality and other non-demographic characteristics are recognized as important attributes in a learner-centered environment. This paper supports the notion that, prior to the start of instruction, the most effective instructors will critically review and consider a range of pedagogical approaches to STEM learning and implement learner-centered experiences that consider students' values, beliefs, experiences, and characteristics.

2.0 Literature Review

While the subsequent review of background literature is not a full exploration of the scholarly work on diverse learner types, it examines multiple perspectives from recently presented scholarship at the American Society for Engineering Education (ASEE) annual conference as well as other academic work that serve as background resources. This section aims to introduce published work relevant to the conceptualization and design of this research project. Discussion later in the paper relates our findings back to this body of knowledge.

2.1 Learning styles, patterns, and pedagogical responses

Peeples et al. [4] provide a conceptual framework for the application of diversity in higher education, regarding institutional and faculty preparation. The authors delve into questions of faculty preparation for engaging with diverse learner types as well as institutional methods of increasing presence and success of those learner types within STEM programs. Peeples et al. [4] focus on institutional programs that increase opportunities for research and collaboration with faculty mentors, e.g. Upward Bound, Questbridge, and research scholarships. The authors conclude that these programs offer underrepresented students more immersive experiences in STEM, and that these disproportionately benefit students who perform best in experiential settings, as evidenced by their higher levels of motivation and achievement. Furthermore, the authors call for higher levels of faculty engagement with, and support of, diverse learner styles, toward building diversified teams of problem-solvers. The authors push against the traditional rhetoric of diversity as an end in itself, and advocate for statistically balanced representation in the student population and attention to diverse learning styles.

By examining the ABET EC 2000 Criteria, Smith [5] concludes that the proposed criteria will be difficult to achieve by certain students unless current engineering curriculums and pedagogical approaches are radically restructured. Smith ([5], p. 2) states, "student learning styles encompass the spectrum of classifications, but faculty can typically teach to only a fraction of these learning styles within their constraints of time and resources." Accordingly, the author evaluates the usefulness of various technologies in delivering content to a wider range of student learner types. Smith's research supports the importance of providing faculty with more comprehensive profiles of student learning styles in order to cultivate a learning environment that supports a greater diversity of STEM students.

Angolia [6] uses foundational theories of learning styles and Kolb's experiential learning theory among others to assess the competency requirements outlined in the Engineering Management Body of Knowledge. Angolia adapted Kolb's model and emphasizes both student inquiries and responses to classroom material—i.e. accommodator/concrete experience, diverger/reflective observation, assimilator/abstract conceptualization, and converger/active experimentation. The model seeks to identify diverse learner styles and gears classroom material towards active, rather than passive learning. The Felder-Soloman model emphasizes cohesion between "learning and teaching styles" (5), p. 6). The model calls for preparing instructors for a mélange of learning styles in the classroom toward curriculums and pedagogies that "challenge students to step outside their comfort zone" ([6], p. 3). Unlike the MBTI or Kolb's models, the Felder-Soloman index maps learning styles across spectra: the first, from sensory to intuitive; visual to verbal; active to reflective; and sequential to global. Notably, the Felder-Soloman Index does not encompass personality traits, e.g. introversion/extroversion.

Roy and colleagues [7] assessed best practices in administering Massive Open Online Courses (MOOCs, e.g. Coursera), and endeavored to analyze learner patterns that emerge from the "tremendous amount of data" originating from the amount and quality of participation in MOOCs. The authors assert that data often considered demographic—such as socioeconomic status, race, or gender—constitute essential components of building an effective tool for examining learner patterns. Roy et al. [7] propose the following MOOC learner patterns based upon clustering, supported by statistically significant T-tests: i. Fully Engaged Learners, ii. Consistent Viewers, iii. Sporadic Learners, iv. One-Week Engaged Learners. Similar to Smith's [5] reliance on the Kolb and Felder-Soloman models, Roy and colleagues suggest that better understanding learners is an important step to developing effective teaching methods, yet they stop short of including personality traits and other characteristics in their scope of consideration.

2.2 Personality characteristics

The Myers-Briggs Type Indicator (MBTI), notably mentioned in the introduction, is a longstanding and well know measure of personality types. The MBTI is generated using a short questionnaire and responses are mapped against four axes; (a) introversion-extroversion, (b) intuition-sensing, (c) thinking-feeling, and (d) judging-perceptive. The MBTI results do not, of course, imply that 'thinkers' do not feel or that extroverts behave in introverted ways at times. Rather, the MBTI offers a heuristic for how people "typically" respond to situations. Stress, emotional situations, and the presence of other people can strongly influence expressions of personality [8]. As MBTI relates to engineering students, Rosati [1] demonstrated the "most successful" engineering student is likely to identify as the INTJ personality type, acknowledging additional factors (i.e. gender and nationality) as contributing to the likelihood of retention. Felder and Brent [3] built upon this initial finding to further explore differences among students in engineering programs with the MBTI. The MBTI, while well-known and previously applied to engineering students, is limited in its ability to analyze the breadth of personality types.

The Big Five Index (BFI) is regarded as an important instrument for characterizing personality. John and Srivastava [9] shared the historical roots and forms of measurement including: Extraversion; Neuroticism; Contentiousness; Openness to new experiences; and Agreeability. The full instrument can be divided into discrete sub-scales for each of the five factors that are independently validated [10]. The BFI is well regarded for its ability to reliability measure personality characteristics and is widely preferred over MBTI in that it covers much of the same material, yet extends beyond the MBTI's measures.

2.3 Values, morals, and ethical foundations

Graham and colleagues [12] advanced the concepts that underpin the Moral Foundations Questionnaire (MFQ) as a means to understanding and analyzing a person's moral domain in ways that extend beyond many of the traditional 'value intensive' surveys, such as those probing empathy and justice. Their work addresses Harm/Care, Fairness/Reciprocity; Authority/Respect, and Purity/Sanctity, and Loyalty/Perfidy. At the 2017 ASEE conference, Mark Bourgeois [13] applied the MFQ to address "harm, fairness, loyalty, respect for authority, and sanctity" (p. 10). The MFQ focuses on how people report their values and how they would ideally respond to certain social conditions. The MFQ and VIA (Values in Action) complement one another in probing morality-based distinctions between individuals. The breadth and depth of the VIA instrument captures data on a wide-ranging set of character strengths. Peterson [11] offered reflections on the approach and situated it within the field of positive psychology.

Dunlap et al [14] significantly revised an earlier survey that probed issues of environmental values to create the New Ecological Paradigm (NEP) instrument. That work was followed up with an article by Dunlap [15] that showed how the instrument is gaining broader attention and application in an article titled, "The New Environmental Paradigm Scale: From Marginality to Worldwide Use" in the *Journal of Environmental Education*. Together, those two papers introduce and demonstrate how the survey was designed and how the questions were refined and validated. At the ASEE conference, the instrument is infrequently mentioned. For example, Simon and colleagues [16] used the survey as part of their research on an introductory course about renewable energy and looked at pre-post changes among the students in the course. After our review of the ASEE conference proceedings database, we note that Shealy and colleagues ([17], p. 19) incorporated the NEP item, "When humans interfere with nature it often produces disastrous consequences", along with others represented in the NEP. Yet, they did not include any of its negatively coded items, which is concerning. Use of positively coded items from the NEP without any of its accompanying negatively coded items could pose unnecessary risk for positive response bias in the resulting data set.

3.0 Research design and methodology

This work-in-progress seeks to better understand the heterogeneity among students and identify shared learning types of STEM students as a precursor to designing learner-centered ethics modules. Learner types are conceptualized as the integration in learning styles, personality characteristics and strengths, as well as value-based and moral foundations. The four partner organizations, mentioned above, are all STEM degree granting, higher education institutions. One is an all-women's school, another is a historically black college or university (HBCU), the third is a large, private Catholic university, while the last one is a secular, large public research university. The structure of this study allows us to explore specific questions: Do STEM students at the different institutions express shared learner types irrespective of the university? This question is critically important, as it brings into question the design of courses that can serve STEM students at different universities and the extent to which course designs can be adapted to the students enrolled at the different campuses.

To explore this question, an instrument was designed to capture data on personality characteristics and moral foundations. The survey, distributed at the outset of the semester, consists of questions informed by theories on personality, character, and values. Specifically, the instrument draws primarily from the Big Five Index (BFI), the Moral Foundations Questionnaire (MFQ), Virtues In Action (VIA), and New Ecological Paradigm (NEP). The use and integration of questionnaires exploring personality characteristics and value-based positions appears to be novel to the field of engineering education in general and engineering ethics education, particularly. The survey additionally contained demographic information, questions about religious identity and practice, and items related to the student's learning environment, such as academic major and extracurricular activities.

Students (n=668) enrolled in participating courses at the four partner institutions were recruited to complete the survey. In the past two years, 264 students completed the survey at a response rate of 39.5%. Students were required to respond to five discussion board prompts that pertained to ethics across STEM fields, but only those responses authored by students who both consented to participate in the study and completed the survey were captured in the data collection process. Any individually identifying information, including names and emails, were removed prior to analysis.

Data analysis was performed in R using factor analysis from the psych[i] package on the survey data. Then clustering the factor scores using a penalized approach. The sparse clustering was chosen over the traditional K-means to avoid noise in weak traits and to cluster on dominant traits of the individuals. Structured Topical Modelling (STM[ii]) analysis was applied to the students' responses to the discussion board prompts. The STM analysis offers results from Intertopic Distance Mapping via multidimensional scaling, whereby student-responses to the discussion prompts are grouped with shared terms into what are called "topics". Then, topics are isolated by physical distance between the marginal topic distributions and visually represented by degrees of overlap or differentiation between topics. The analysis reveals the top thirty "terms", which are the word stems such as, "scienc" or "offici" and are generated after excluding such words as, "the, or, and". STM analysis groups words with similar word stems including science and sciences as "scienc" or official and officials "offici". Then each topic can be further interrogated by selecting it individually and those terms (represented by word stems) that are most salient to that topic are highlighted in red and the ordering of the top 30 terms changes by topic. The salience of the terms is based upon equations published by Chuang et al. [18] and shown in the results. For all analysis performed in this paper, the relevance scale (λ) was set to 0.5, which is generally the accepted norm—c.f. Sievert & Shirley [19] for details on setting relevance scales for STM analysis. This analysis reveals the diversity of learner types that students express via the survey and can augment the typical ways that instructors adapt their STEM ethics courses in ways that engage with the values and personalities present in the classroom.

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[i] The psych package can be found at: https://cran.r-project.org/web/packages/psych/psych.pdf
[ii] The stm package can be found at: https://cran.r-project.org/web/packages/stm/stm.pdf

4.0 Results

The results described here are preliminary and share our work-in-progress to better understanding the STEM students in classrooms in diverse university. What is readily apparent is that the integration of personality characteristics and value-based positions is useful to more holistically describe learners. The cluster analysis offers some initial insights into sub-groups of students that share traits, shown in Figure 1. The STM analysis demonstrates how student-responses to the same prompt in the discussion board can vary greatly. These two pieces of evidence reveal key personality characteristics and articulate value-based preferences that are critically important for teaching engineering ethics.

4.1 Cluster Analysis of Survey Data

Survey data was analyzed to explore some initial clusters across the participating schools. Using K-mean clustering methods the 264 students were clustered into eight groups along spectra for each sub-scale relative to the other study participants. The sub-scales selected for this analysis were derived from an iterative process by the research team that started with an exploratory dataset that was qualitatively analyzed for key personality characteristics and value-based positions. That qualitative work formed the basis for a logic model that was iterative tested against the larger dataset using clustering techniques. The research team selected the following six scales with the scale abbreviation in parentheses:

- BFI Extroversion (bfiExtraScore)
- MFQ Authority subscale (mfqAuthScore)
- MFQ Fairness subscale (mfqFairScore)
- VIA Equity subscale (viaEquScore)
- VIA Valor subscale (viaValScore)
- NEP Scale (nepScore)

The results from this K-Mean Clustering with these six survey scales yielded eight discrete profiles of learner types that integrate a person's personality characteristics and value-based positions. The clusters are illustrated in the heat map in Figure 1, below. To bring these profiles to life, we describe each profile (or cluster) briefly for illustrative purposes.

Students in Cluster 1 demonstrate a relatively high care for the environment (NEP-Scale), yet are introverted (BFI-Extroversion) relative to their peers and critically think about the rules that govern society. Whereas, Cluster 2 share a high level of concern for fairness and equality (MFQ Fairness) in society and believe that rules are important to uphold those values (MFQ Authority). Students in Cluster 2 are relatively introverted (bfiExtraScore) as well as rule abiding persons that believe in justice and fairness. This cluster includes 49 out of 264 student-respondents, and thus it represents a considerable proportion of the STEM students involved in this study. This suggests that it is important to routinely offer educational activities that do not rely upon large group discussion or interpersonal dialogue, such as reflective thought and writing.

The students in Cluster 3 have a propensity for direct interpersonal interaction (bfiExtraScore) and might best be called "Eco-Advocates" as they place a high-level of importance on ecological issues (NEP Scale), as well as justice and fairness (VIA Equity). These students score the lowest on the measures of authority (MFQ-Authority), as well as the highest score for bravery (VIA-Valor); thus, they recognize justification to question the agencies of power in their lives and they are brave enough to do so. These students might be well-served by role playing activities in which they can communicate verbally and take on roles that challenge authority or advocate for what they perceive as just. The students in this cluster are likely to challenge their peers, as well as the instructor.

Cluster 4, while also extroverted, prioritize rules and respect for authority. These students believe that rules are important to maintain societal boundaries and to direct ethical decisions. These students would be likely to express leadership characteristics in group activities, and may be highly challenged by activities that bring up issues of 'whistle blowing' or instances where conformity resulted in negative consequences. Students in Cluster 5 express relatively lower concern for the environment, issues of fairness (MFQ-Fairness), and equality (VIA-Equity). These students score relatively introverted and might be the "Quiet Critic" in the back of the classroom who is unsure about why many peers are so concerned about the environment and perceived issues of justice.

Cluster 6 includes those students that don't see themselves as brave (low score on VIA-Valor) and are introverted. These students are not generally concerned about equality, relative to their peers. In Cluster 7 are the students that share the least concern for the environment relative to their peers and they can be outspoken (slightly above average BFI-Extraversion). The final group, Cluster 8 shares two characteristics in a slight disrespect for authority and rules and the lowest average responds to questions of fairness. These students generally disagree with statements such as, "When the government makes laws, the number one principle should be ensuring that everyone is treated fairly" and "Justice is the most important requirement for a society," and "I think it's morally wrong that rich children inherit a lot of money while poor children inherit nothing". With 22 students in this final cluster and few other distinguishing characteristics, this group is an intriguing sub-population in our classrooms. Overall, instructors might intuitively recognize some of these subpopulations, the authors certainly do, and can think of specific students who are emblematic of these groups. More in depth analysis of the student-writing in consideration of these clusters is needed to more thoroughly understand these initial (work-in-progress) results, as discussed in the limitations, below.

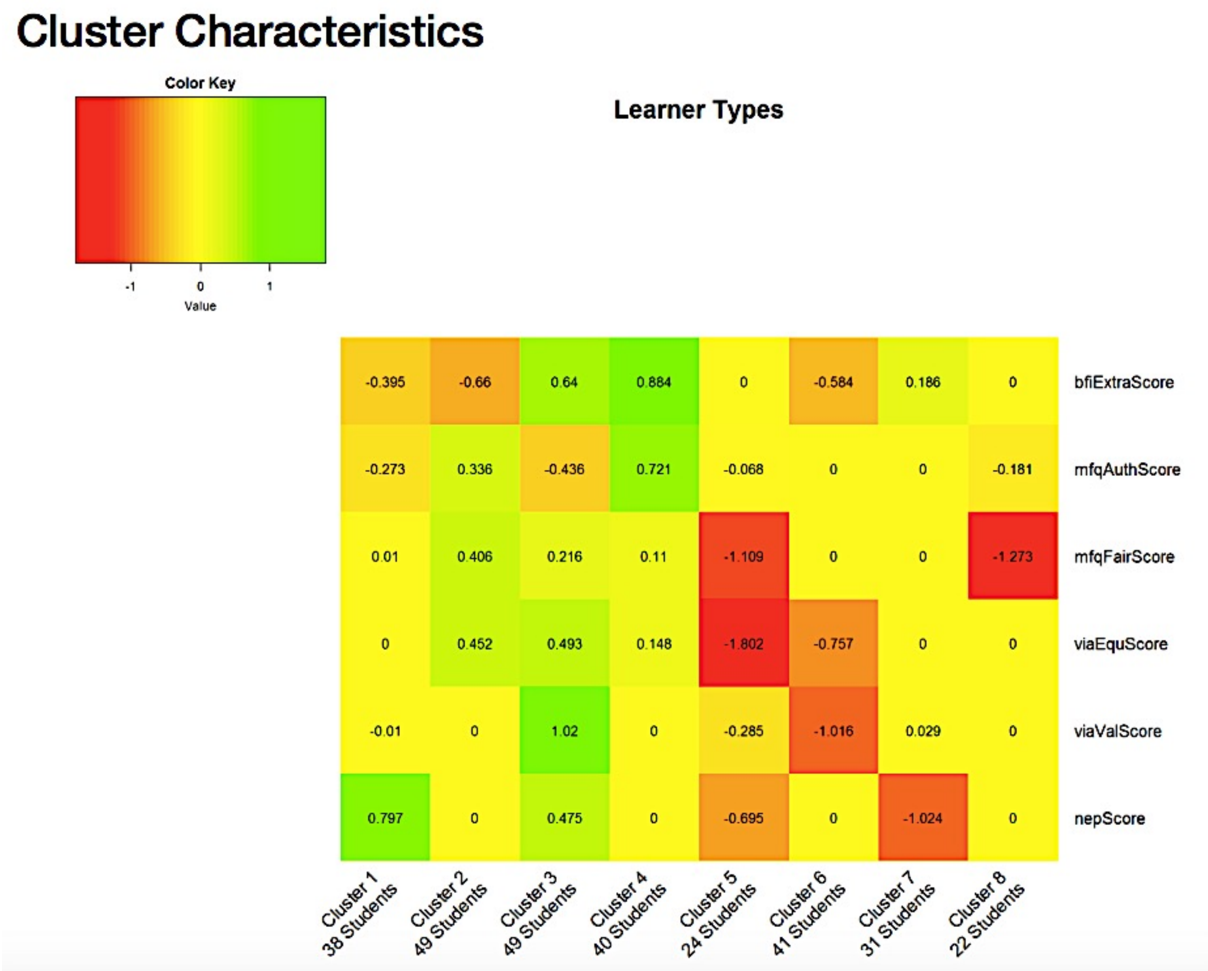

Figure 1. Cluster Characteristics sorted by eight Learner Types. This figure depicts all eight clustered learner types against the six survey scales from top to bottom: bfiExtraScore = BFI Extroversion subscale; mfqAuthScore = MFQ Authority subscale; mfqFairScore = MFQ Fairness subscale; viaEquScore = VIA Equity subscale; viaValScore = VIA Valor subscale; nepScore = NEP Scale. The color key shows relatively positive scores on a spectrum towards green and relatively negative scores towards red with yellow as neutral (0).

4.2 Structured Topical Modelling (STM): Comparison with Discussion Prompt 3

This section demonstrates how STM can be used to group student-writing on the basis of the frequency of the terms (or key words) used in their responses to the discussion prompt. This analysis groups the student-responses into clusters of responses with similar terms and are called "topics". The topics are differentiated from one another based upon the frequency of terms as well as the uniqueness of the terms in the student-responses posted to the discussion board. In this section, we focus on the student-responses to one discussion prompt simultaneously shared across all four participating institutions to illustrate the diversity of responses to the same question using a highly qualitative method. This section shares our work-in-progress to analyze student-responses to prompt: *Which factors contribute to the ethical practice of science and engineering- Moral upbringing? Laboratory leadership? Institutional environment-and how could these factors be combined more effectively toward cultivating cultures of ethical STEM?*

For interpretation and clarity, please note that in the following figures (Figure 2-6), the top-30 terms are ordered by relevance to the red highlighted "topic" (or student-responses cluster). The light-blue extensions of the bar graph (on the right side of each figure) indicate all the other uses of a given term in the corpus of text, i.e. all responses to the prompt. The term "token percentage" is the percentage of the total terms within the selected topic in relation to all the terms captured in the corpus of text. The student responses to the prompt yielded five, distinct "topics" (or clusters) and shows high divergence between the separate topics and the terms in each reflect highly disaggregated student-responses. Each "topic" is interpreted in turn, from largest to smallest in regards to the number of students that were grouped into the topic. The interpretations of the student-responses are exploratory and a sample from each cluster will need to be taken and subjected to a full read by a member of the research team for more robust explanations to be developed. This limitation is expanded upon in section 5.0.

The largest topic contains 33% of the total number of "tokens" or qualifying terms, see Figure 2. The topic is does not overlap with any other topics and is thus distinct. Looking back at the prompt and then at the list of terms at the top of this list, a few things are apparent. The student-responses tend to include words from the prompt in their responses to it. This may be attributable to students' intention to articulate a response to the prompt that is clearly direct. It is also possible that, in some cases, students lean on the instructor's prompt as a means to guide their responses in a situation where there is no clear 'right answer' to give. The terms "young" and "play" (23^{rd} and 24^{th} most frequent tokens) were unique to these student-responses and suggests that the responses emphasize early-childhood development as important in the cultivation of ethical STEM.

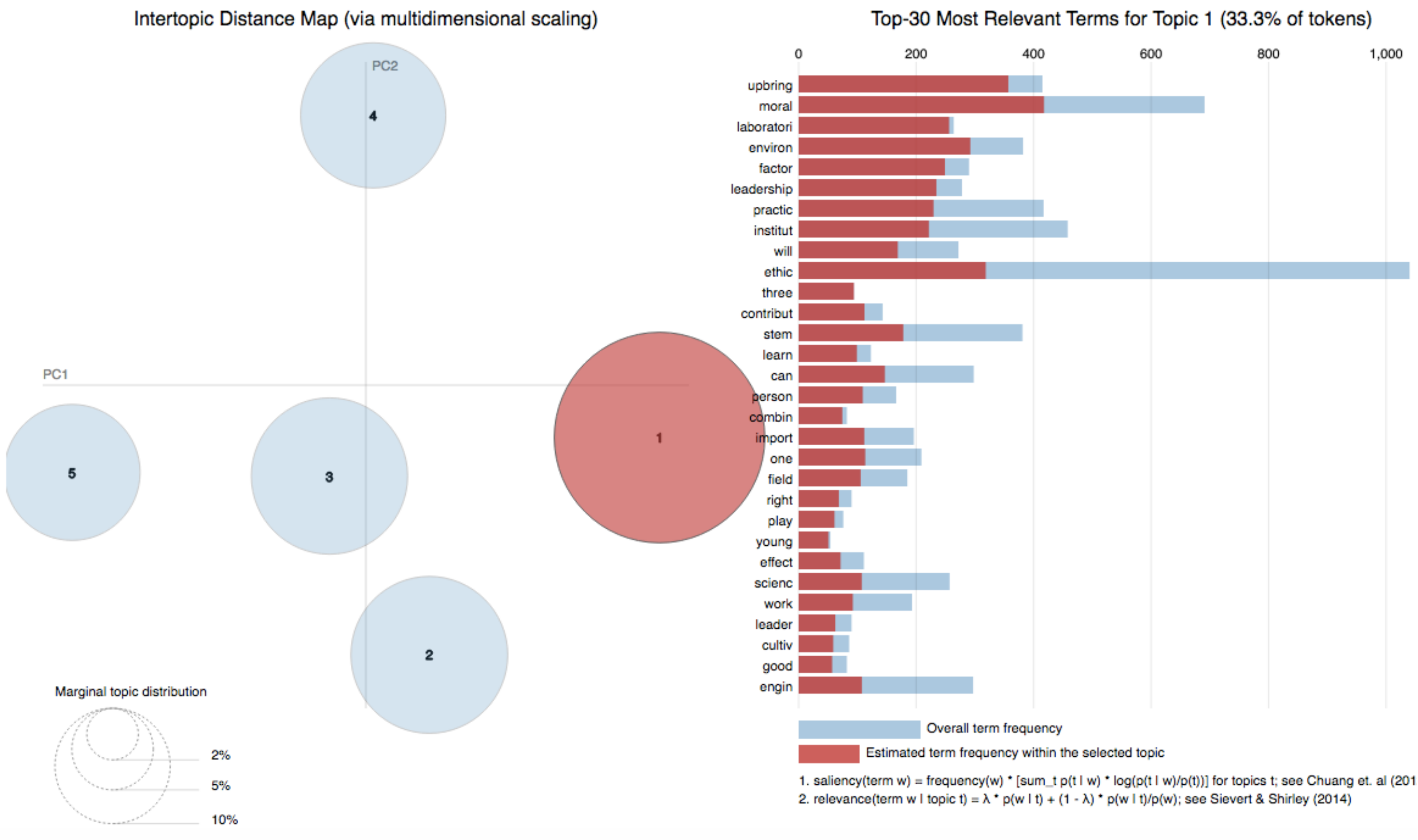

Figure 2. Structural Topic Modeling of Discussion Board Prompt with Topic 1 in red.

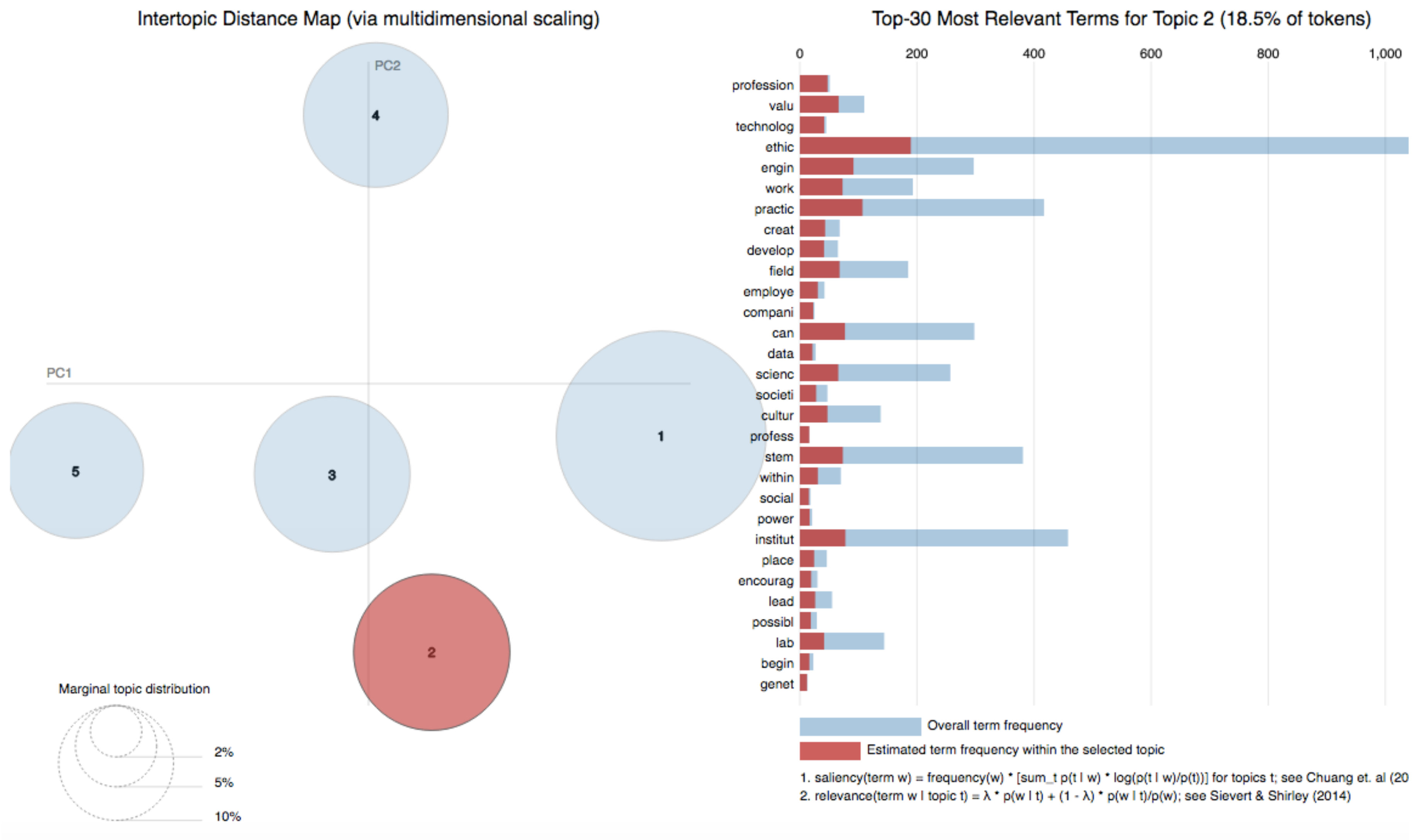

Figure 3. Structural Topic Modeling of Discussion Board Prompt with Topic 2 in red.

Topic 2 is the second biggest (18.4% of total terms or tokens, see Figure 3 above) and is distinct as the student-responses use the terms, “profession”, “valu”, “work”, “practice”, as well as “employe” and “compan” and “societ”. This collection of terms suggests that the student-responses center on the cultivation of ethical STEM as an important part of professional development in companies and professional societies. These students might be expressing the notion that values and ethics are learned as part of the enculturation in work or through other professional development activities. This suggests that these students are following Herkert’s [20] notion of professional societies and firms as mediators of ethics. Further, these terms bring to mind the concept of corporate social responsibility and the company-employee relationship as important to a person’s ethical practice.

Positioned right in the middle of Figure 4 is Topic 3. The root words contained in the student-responses harken back to Michael Polanyi’s 1962 article, “The Republic of Science” [21]. The student-responses are filled with terms like, “scientist”, “scienc”, “research” and others such as “train”, “instructor” and “enforc”. This collection of terms reflects notions that ethics are learned in scientific labs and through trainings from instructors, researchers, and the scientific process. Student-responses may thus reflect an emphasis on an inextricable link between the self-governance of science and its ethical practice.

Topic 4, highlighted in Figure 5, is the second smallest (15.9% of terms). This topic is defined by words such as, “decis”, “peopl”, “individu”, “situate”, and “immor” (stem word of immoral or immorality). The terms suggest that the student-responses refer to decisions that are made by people, specifically individuals within particular situations. These decisions can be understood as moral, ethical or immoral. This collection of words may reflect an individualistic understanding of STEM ethics, rather than the professional society and corporate cultures of ethics that are expressed in Topic 2. These students may lean toward a libertarian set of values, and a qualitative analysis of student responses is underway to investigate that interpretation.

Figure 6, below, highlights the smallest topic that is on the left side of the figure. The topic is characterized by terms including, “money”, “fund”, “project”, “corpor”, “motiv”, “uneth”, “behavior” and “incent”. These terms indicate that the student-responses centered around the influences of money, funding and corporations on STEM ethics. This topic is markedly different in that the root term “unethic” forms either unethical and unethically. The word “company”, as used in Topic 2 is associated positively with ethical, while when student-responses feature the term “corporate” or “corporation” it is used in a negative manner as associated with “unethic” here in Topic 5. These student-responses might be characterized as skeptical of private interests and the influence of funding on science and engineering, based on a recognition that money may frequently be a powerful driver toward unethical decisions and behavior.

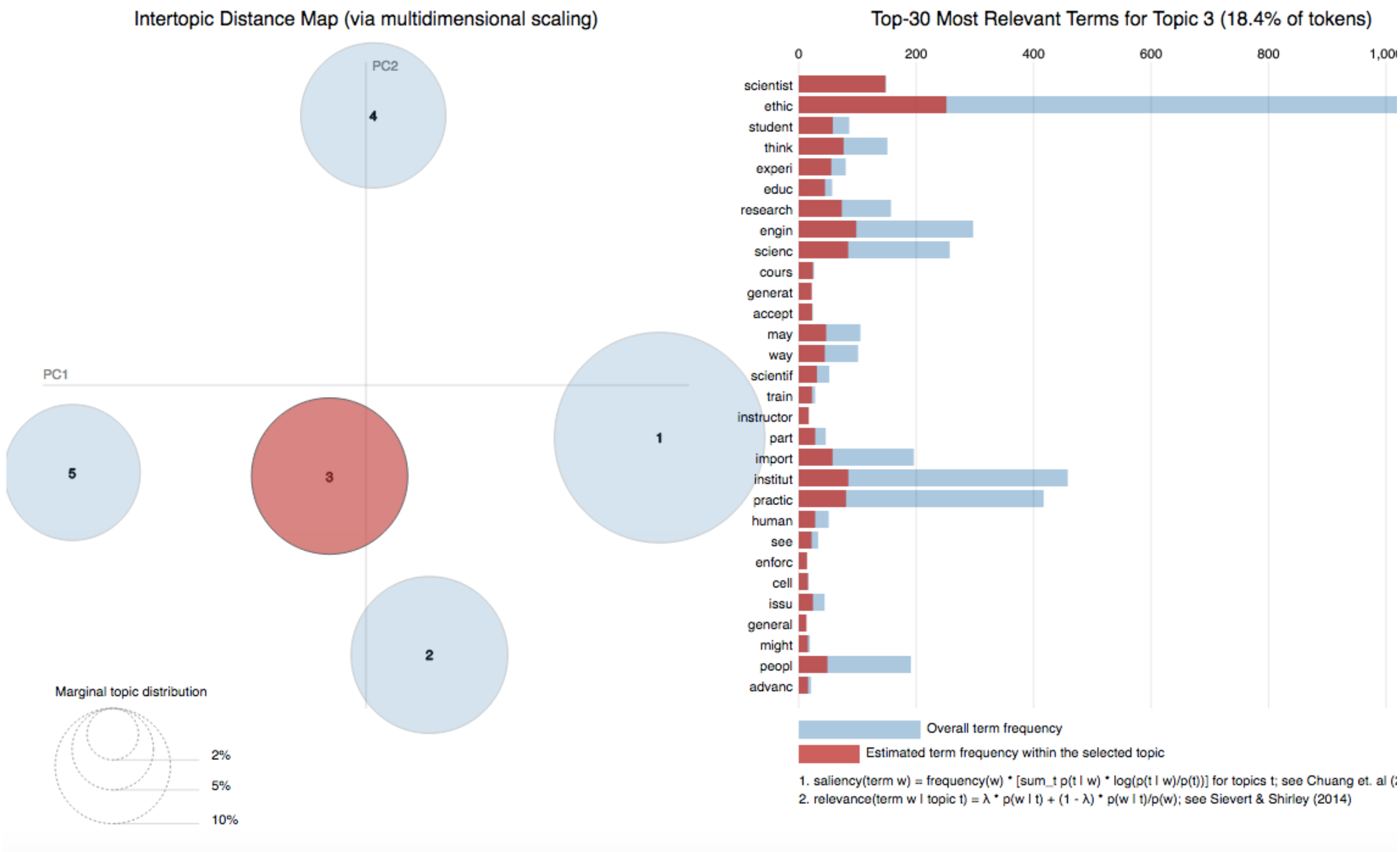

Figure 4. Structural Topic Modeling of Discussion Board Prompt with Topic 3 in red.

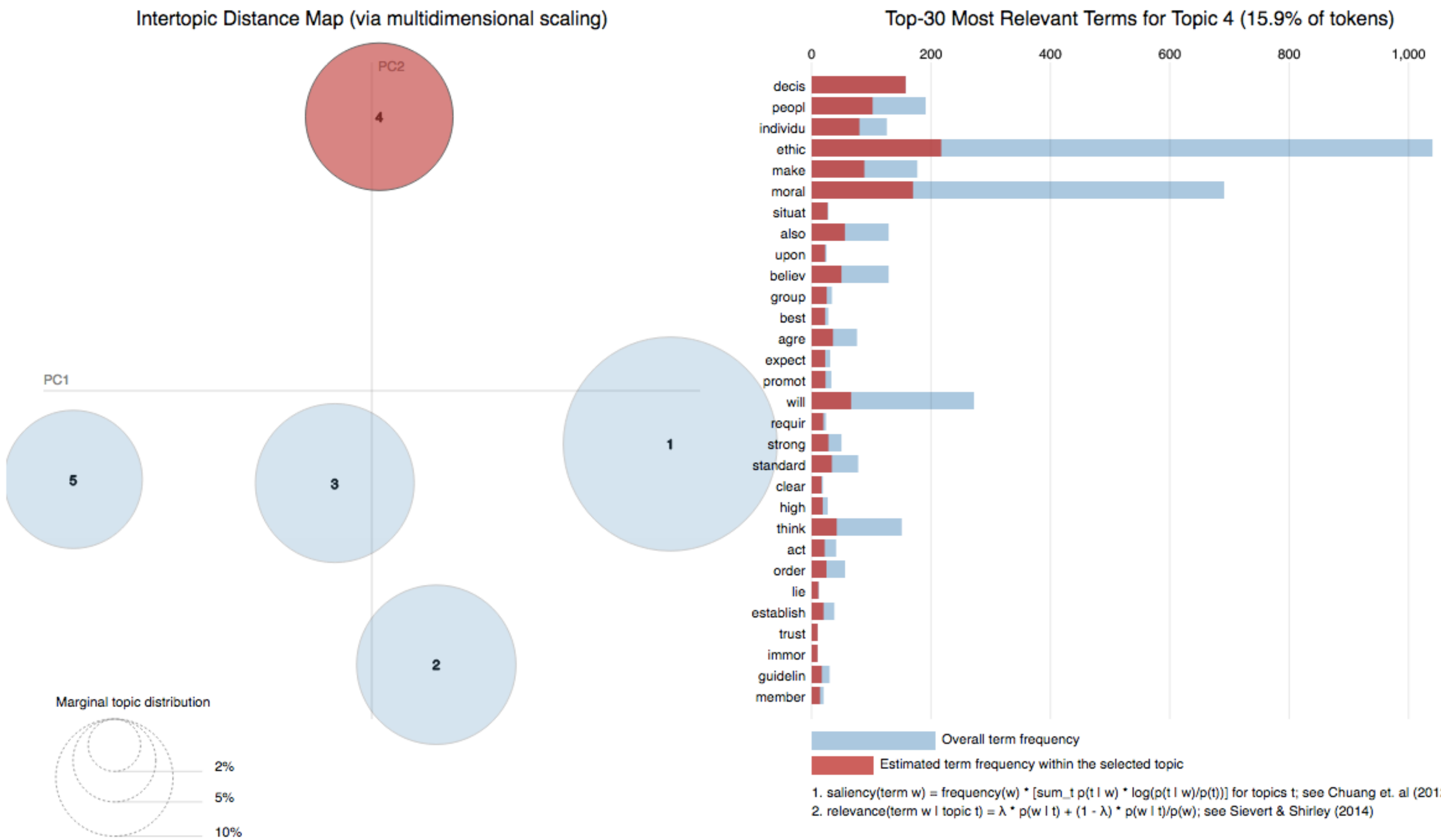

Figure 5. Structural Topic Modeling of Discussion Board Prompt with Topic 4 in red.

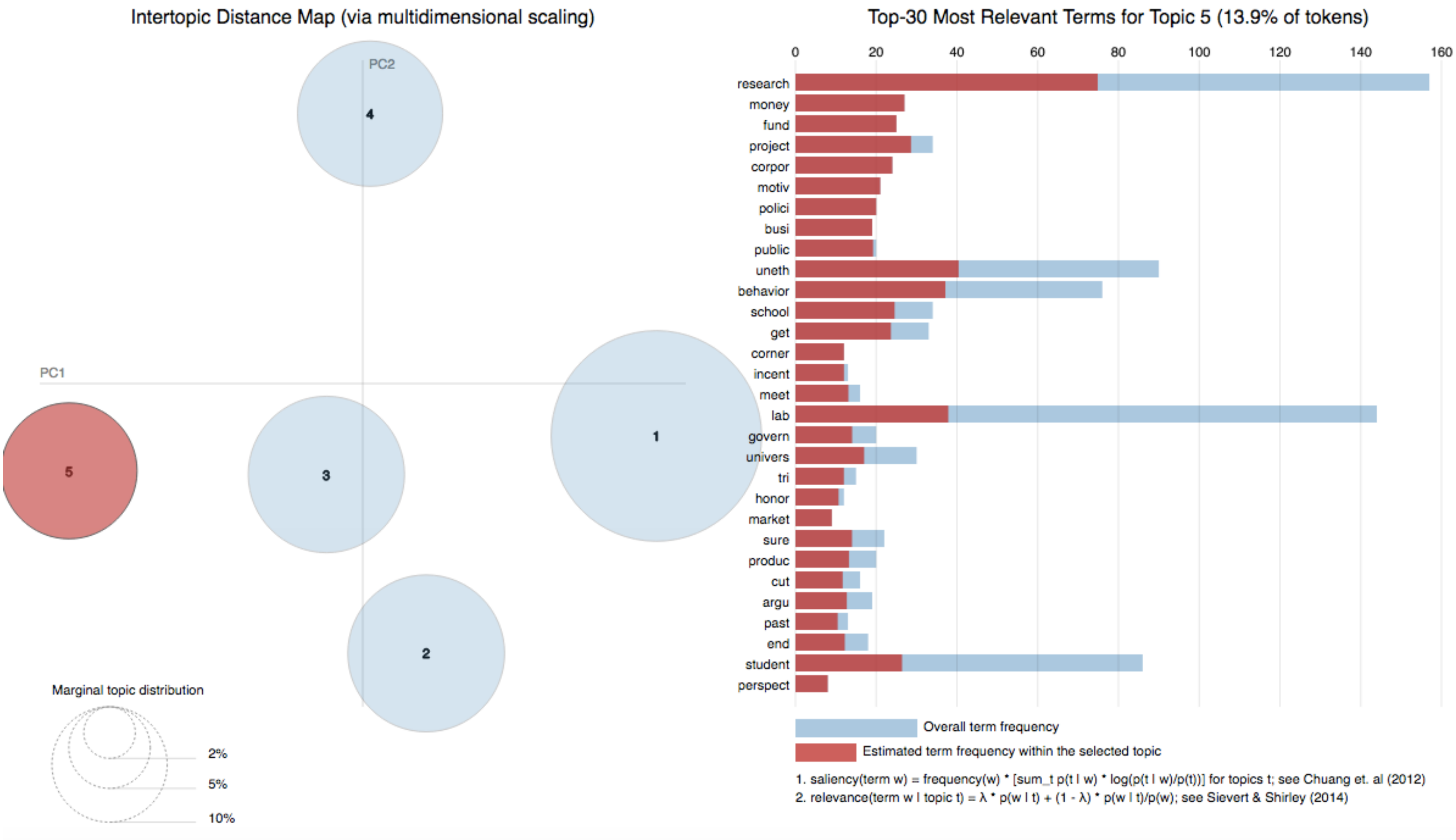

Figure 6. Structural Topic Modeling of Discussion Board Prompt with Topic 5 in red.

4.3 Synthesizing clustered learning types and student-writing

Quantitative and qualitative analyses are ongoing, toward validation of the results presented above regarding learning types and clustered student-writing, with an aim toward integration of findings into STEM ethics education materials and practices. Quantitative data can offer insights from larger, aggregate data sets, though qualitative data is needed to enrich our understanding. The next steps in this research project, which is a work-in-progress, is to validate (with qualitative data) those clusters and then to look for correlations between the learner types and the student writing. Our working hypothesis is that student-responses to the prompt will be related to the learner types derived from the pre-course survey. This opens up interesting avenues for research, course-design and pedagogy. As for research, questions about the "diversity" of students in the course quickly moves beyond demographics. Further, we will pursue the question of how ethics courses and classroom activities can be designed to engage such a diverse group of STEM students, who exhibit heterogeneity far beyond simple bifurcations (extroverted versus introverted). Learning experiences and outcomes need to be more fully understood in relation to learner types. The goal is to design STEM ethics learning experiences that go beyond teaching "right from wrong" in a "one size fits all" manner, toward engagement of students' personality characteristics and values as they learn about ethical theories, ethical inquiry, and how ethics informs their own and other's decisions.

5.0 Discussion and concluding points

As Angolia [6] and Felder & Brent [3] showed, there is a need to think of students as diverse learners, integrating personalities with a broad spectrum of additional traits. This research pushes against the earlier work by Rosati [1] and advances that central notion that engineering students (and STEM students more generally) cannot be 'typecast' in one way. This is a diverse learning community with observable variation in behavior and beliefs. Through analysis of characteristics such as extraversion, valor/courage, equity/fairness, and environmental conscientiousness we strive to holistically understand STEM learner types in order to improve their ethics education outcomes and experiences.

The student responses to the discussion prompt illustrate divergent thinking about a central issue in engineering ethics (and STEM ethics more broadly), offering insight into how they internalize the question and bring their own experience to bear on it. These aspects demonstrate significant learner heterogeneity that goes beyond the 'skin deep' dimensions of demographic diversity tracked by university administrators. The challenge for future work is to offer STEM ethics learning experiences that take into account such divergent thinking and support all learners to engage with ethical theories, inquiry and analysis.

There are numerous facets to this evolving research project, a work-in-progress, that are left unexplored in this initial paper. The mean scores are vulnerable to aggregation errors and can be highly influenced by outlier data points. The clusters of learner types are descriptions of shared characteristics within groups and are not correlations of shared traits. Additional analyses will explore the relations (and potential correlations) between the clustered learner types as informed by survey components, demographic data, religious identity and practice, and results from student writings. We expect that as data collection continues and a larger sample size is obtained, data analysis will be more robust and reveal statistically significant results.

The STM analysis and our initial interpretations need to be verified (or reworked) based upon qualitative analysis of the student-responses. The fundamental limitation in the results is that STM offers an intriguing analytical approach to clustering the words expressed by students in the discussion posts. Yet, there is no contextual information about what the students are expressing with those words. The word-stems associated with each topic cannot be understood normatively without such qualitative analysis. Thus, these initial results are neither indicative of what is the right way to cultivate ethics nor do they illustrate student-perceptions of the wrong way to cultivate values in engineering. Further, as noted above, the research team will need to address how to best deal with the restatement of words from the prompt in the student-responses. Nonetheless, the STM demonstrates a high diversity in the thoughts expressed by the students and offers a novel means to better understand how students approach the cultivation of ethics in engineering (and STEM) ethics education.

Recognizing the many relevant forms of diversity among students and finding out what resonates with different types of learners are essential first steps to effectively reconceptualizing ethics learning experiences, toward the cultivation of ethical STEM cultures. There is a need for instructors to critically reflect upon the notion that discussion-based activities can disproportionately benefit extroverted persons and may isolate or diminish the engagement by people that are more introverted. There is also a need to consider how diversity among the student body can be understood vis-a-vis ethical theories, inquiry and decision-making. For example, if a student enters the classroom with a rule-following sensibility about the world (deontological position), how can educators engage such a student from that starting point, along with advancing the student's appreciation for alternative world views and divergent ethical positions? To enact a learner-centered approach, it is imperative that instructors take into account the diversity of learner types, personality characteristics, and prior moral foundations in re-thinking and re-designing their ethics-related curricula. This research takes a step in that direction and treats students not as 'empty vessels' devoid of prior ethics training and moral foundations, but rather seeks to meet diverse students where each of them is in order to meaningfully engage with them on the cultivation of ethics in engineering and STEM fields.

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