Student Perspectives on Cognitive Engagement: Preliminary Analysis from the Course Social and Cognitive Engagement Surveys

Ms. Allyson Jo Ironside, Oregon State University

Ally Ironside is a recent graduate from LeTourneau University where she studied Water Resources in Civil Engineering. She is currently fusing her technical background with her passion for education in pursuing a doctoral degree in Civil Engineering while conducting research in Engineering Education at Oregon State University. Her research interests include the adoption of teaching best practices in engineering and the personal epistemology development students.

Dr. Shane A. Brown P.E., Oregon State University

Shane Brown is an associate professor and Associate School Head in the School of Civil and Environmental Engineering at Oregon State University. His research interests include conceptual change and situated cognition. He received the NSF CAREER award in 2010 and is working on a study to characterize practicing engineers' understandings of core engineering concepts. He is a Senior Associate Editor for the Journal of Engineering Education.

Mr. Benjamin David Lutz, Oregon State University

Ben Lutz is a Postdoctoral Scholar in Engineering Education at Oregon State University. His research interests include innovative pedagogies in engineering design, conceptual change and development, school-to-work transitions for new engineers, and efforts for inclusion and diversity within engineering. His current work explores how students describe their own learning in engineering design and how that learning supports transfer of learning from school into professional practice as well as exploring students' conceptions of diversity and its importance within engineering fields.

Student Perspectives on Cognitive Engagement: Preliminary Analysis from the Course Social and Cognitive Engagement Surveys

Abstract

The following is a research paper centered around the discovery of the meaning of engagement to students and researchers. Increasing student in-class engagement remains a goal of the engineering education community, yet faculty continue to lack tools that allow them to measure their students' engagement. Development of tools surrounding engagement connects faculty to the best practices emergent from the research. Critical aspects of survey development include not only psychometric validity, but also shared contextual meaning among researchers, educators, and students. That is to say, instruments can have validity and reliability, but might not necessarily provide useful feedback to the faculty using them. The ways in which students' self-report is one way both faculty and researchers can make meaning of survey responses. As part of a larger research study, we used an innovative model to develop a survey tool to measure student's in-class cognitive engagement under Chi's **I**nteractive/**C**onstructive/**A**ctive/**P**assive (**ICAP**) framework. Students were included in the development process as a means of gaining understanding of their interpretation of survey items. We interviewed student survey participants, asking them to both explain what they believed the survey to be asking them and what actions shaped their responses. The purpose of this paper is to understand potential discrepancies between researcher intention and student interpretation of quantitative survey items. To that aim, we ask the following question: *How do students interpret survey items related to in-class cognitive engagement?*

Preliminary findings suggest students' interpretation of items points to a discrepancy between researcher and student meaning of engagement. Though the survey was intended to target in-class engagement, students often conflated their in- and out-of-class engagement behaviors. Moreover, students did not distinguish between language we intended to reflect different levels of cognitive activity. As we continue to develop surveys surrounding engagement, this study gives useful insight into how we can interpret student responses and provide meaningful feedback to faculty. This is accomplished by understanding the ways in which researchers, faculty, and students talk about engagement differently, and how that might lead us towards shared meaning.

Introduction

Engineering education research has historically paid much heed to student engagement [1]–[3]. Despite continued reinforcement as a classroom best practice [4], [5], there are a lack of tools to measure student engagement. One potential reason for a lack of tools is a lack of consensus among researchers regarding the meaning of engagement. Fredricks, Blumfeld, and Paris synthesized much of the existing research on engagement in 2004, developing a three-part model of understanding student engagement [6]. Students are said to engage behaviorally, cognitively, and emotionally; by understanding all three modes of engagement, a comprehensive picture can be generated of how students are engaged [6]. While an educator may be able to observe the behavior and even social engagement of their students, observation of the cognitive engagement of students proves problematic. To address this issue, Chi and Wylie developed the ICAP framework [7]. The ICAP framework intends to link the often-elusive cognitive engagement to

overt, observable behaviors. Foundational to this study is the use of a survey tool based upon the ICAP framework. This survey, the In-Class Cognitive Engagement (ICCE) survey has emerged from the development of a larger project targeting student engagement cognitively and socially [8]. Development of the ICCE survey remains ongoing. Here, we seek to discuss student perceptions of this instrument. This research is positioned as meaningful towards the larger project aim of measuring student engagement, but also contributory to the body of knowledge surrounding student involvement in survey development.

Literature Review

As previously mentioned, engagement is an important factor in active student learning. While aspects of engagement like behavioral engagement lend themselves well to observable study, cognitive engagement has proved less obvious to observers and thereby is less frequently researched [9]. Research that does exist shows cognitive engagement's positive relationship to desirable student characteristics such as goal orientation, motivation, and collaboration [5], [10], [11]. To link cognitive engagement to a more easily observed and researched trait, Chi and Wylie developed the ICAP framework [7]. This framework, consisting of four modes of engagement (Interactive>Constructive>Active>Passive), with each mode of engagement being recognized by a type of action taken by a student. For example, a Passively engaged student will simply observe a lecture and remain oriented towards instruction. To move into Active engagement, the student begins to take notes from what is being presented by the instructor. The student moves to Constructive engagement when they generate their own knowledge and manipulate the presented material. Finally, should the student choose to share knowledge with their neighbor, they move into Interactive engagement [7]. The framework offers several advantages. By indicating cognitive engagement by behaviors, observations can lead to an understanding of cognitive states of students. Additionally, when prompted, students may be able to more accurately describe their action instead of just discussing how they were thinking. These factors position the ICAP framework as a natural match for the development of an instrument to measure student cognitive engagement.

Our research team has currently been developing such a tool, the ICCE survey, based on ICAP and validated by faculty [8]. Yet, it remains important to connect with the users of the survey, the students, during development. In this way, the assumptions of the ICAP framework can be validated in survey form. This study is situated within the history of work that employs qualitative think-aloud interview techniques as an essential component of survey validity. Such research has shown the importance of feedback as quality assurance for instructors and classroom change [12], [13]. The use of student feedback makes for the better development of an instrument that is meaningful in providing feedback to important stakeholders such as faculty.

Methods

In order to explore further the meaning students attribute to items developed by our research team, we conducted qualitative interviews with engineering undergraduate students. We presented students with the current draft of the ICCE survey containing questions directly linked to overt behaviors and subsequently asked them to explain their interpretation of the items listed. Both *a priori* and open coding techniques were implemented to first characterize engagement mode, and then provide additional descriptive power within each pre-established category. The

following sections provide an overview of the research participants, data collection approaches, the instrument used to guide interviews with students, and the iterative analytic process.

Survey Development

As noted, the survey used in this study is derived from a larger project aimed at measuring students cognitive and social engagement both in and out of class. The present work focuses on students' in-class, cognitive engagement through use of the ICCE survey. For both brevity and clarity, only questions directly related to observable behaviors were used in the modified version of the ICCE survey presented to the students in this study. This allowed for the researchers to delve deeper into how students perceived survey questions while relating them to a concrete form of engagement. The questions provided to students both in survey form and during the interview are seen in **Table 1** below.

Table 1: Survey questions and their correspondence to ICAP modes of engagement

I	*I work with other students to understand ideas or concepts regarding course content.*
	I do not discuss course concepts with other students.
C	*I take notes in my own words.*
	I add my own notes to the notes provide by the teacher.
	My course notes include additional content to what the teacher provided.
	I add my own content to the course notes during lecture.
A	*I take verbatim notes (meaning word for word directly from the board/PowerPoint slide/doc camera etc.)*
	I copy solution steps verbatim (meaning word for word directly from the board/PowerPoint slide/doc camera etc.)
	I only copy the notes the teacher writes down.
	I do not add my own notes to the course notes.
P	*I listen to lectures without doing anything else.*
	I do not think about course content during lecture
	I focus my attention on things other than course content during lecture.
	I do not write notes during lecture.
	I do not pay attention to course content during lecture.

Participants and Recruitment

Participants were recruited from a single class at the research site. The class was chosen as a single case study to evaluate student perceptions of the ICCE survey during the development phase. The class was a junior level thermodynamics course in the department of chemical engineering. The class was selected based upon an interactive classroom environment, large class size, and professor willingness and interest in participation in the research. At the end of the first week of the term, the research team introduced themselves to the class, explained the purpose of the study, and requested student participants who would be willing to complete the ICCE survey and a follow-up interview. The researchers informed the students of the activities associated with consenting to participate in the study. The researchers also told the students that the study would include a survey and an interview about their classroom behavior over the course of the term. The researchers did not give the students specific details of the different types of engagement

that the survey and interview would examine. The research team posted a recruitment document to the class website, which also provided the details of the study and requested participants. In addition, students received $40 compensation for their participation. In total, 13 students were full participants in this study.

Interview Protocol

In order to maximize the effect of student interviews for this study, a protocol for semi-structured interviews for the students who completed the engagement survey was used. Jacobs and Furgerson developed a protocol for student interviews intended for students new to qualitative research [14]. Elements of this protocol were adopted in the interviews used this study. After the student participants had completed the ICCE survey, they sat down in a one-on-one interview with the researcher. To begin the interview, the researcher guided the interviewee through all the questions in the survey, one-by-one. The researcher read each question and asked for the student's interpretation of it. The researcher followed up to ensure the student was explaining why they answered the question the way they did. During these questions, the researcher took notes and wrote down clarification questions to ask the student at the end of the interview. Additional follow up questions by the researcher included questions about the difficulty of the survey. The researcher concluded the interview by reviewing the notes and asking students for any further clarification.

Analysis

The purpose of the analytic approach used here was to gain a deeper, more nuanced understanding of the meaning participants assigned to quantitative probes of classroom behaviors. The final aim was to more closely align survey items with researchers' intentions. To code participant responses, we conducted two waves of analysis. First, we conducted *a priori* coding according to our pre-determined cognitive engagement categories (i.e., ICAP). Following the categorization of participant quotes, the lead Author performed an iterative process of descriptive coding to identify the common aspects within each category of interpretation. The final result is four categories (one for each of the ICAP variables), with accompanying rich descriptions that express students' and researchers' shared understanding of the ICAP variables.

Results

The following results are based off student responses to interview questions regarding the survey they took in conjunction with their course. The purpose of the methods was to generate findings to answer the question: *how do students interpret survey items related to in-class cognitive engagement?* While students were asked to reflect on survey questions individually, results present their collective interpretation of items related to each particular mode of engagement from the ICAP framework. This provides insight in the ability of the ICCE survey to target a student's mode of cognitive engagement. The results point to both general and specific trends in student understanding of the ICCE survey, which serve to inform the survey's ongoing development and validation.

Interactive

When discussing interactive engagement, students seemingly conflated all their experiences with classmates in their course. Despite survey questions targeting student behavior involving interaction in the classroom, students would reference the groups they met with when tackling homework: "**We don't meet every single day, but we meet when we need to.**" This student was not referring to their in-class engagement, rather their out of class interactions. The groups students worked with to complete out of class work were frequently referenced in the interviews. Beyond this, students discussed how their interactions with students outside of class shaped their in-class activities. For example, some students claimed they made an effort to sit by and work with students they already knew.

Wording of the questions and scales did not generate consistent interpretation among students. Some students interpreted the statement *I work with other students to understand ideas or concepts regarding course content* as "**If I was confused about something, how likely would I be to clarify with somebody,**" changing the question from one of description to one of frequency. Other students saw the question asking how likely they were to follow instructions to work with another student in class. Despite instructions stating "*The following items refer to activities you engage in during class without being directed to do so by your teacher*" some students seemed to consider the structure of the class and its allowance for their interaction with others:

> **"It's mostly [the professor] just talking, and the occasional concept… well, not the occasional, the very frequent concept warehouse, and then the occasional 'discuss this with your neighbor.'"**

The two questions discussed as part of the interactive mode of engagement were inversely correlated, meaning a *very descriptive* response to one question corresponded to high interactive engagement, while *very descriptive* on the other question corresponded to low interactive engagement. These inverse correlations proved challenging to students. In the interview setting, one student admitted to failing to read the *do not* component of the question.

Constructive

Questions related to constructive engagement centered around notetaking. The concept of notetaking, and what it meant to add content was interpreted widely by students. When explaining the meaning of *taking notes in my own words*, one student said,

> **"If I'm taking notes based on what the teacher says rather than copying down work that they're doing, then I might paraphrase or word it so I'll understand it better when I read it back"**

In contrast, another student saw notes in their own words to mean copying down words spoken by their professor: **[The professor] would say it and not write it down and so I would just add something [to my notes].**" When speaking of *adding notes to those provided,* a student discussed means of recoding how to locate information:

> **"Say there's this integral, or this derivative, and I would point out this is this variable, and here's where we can go find this in the tables. I would sort of describe to myself how I would use the notes or equations that I'd been given."**

The three quotes above all point towards students' emphasis on the ability of their notes to provide them or direct them to supplemental information. In this way, students saw their own notes as a means of better understanding the material or emphasizing an important topic.

As was seen with interactive engagement, some students believed the additions they made to their notes outside of the classroom classified as *additional content*. This conflation between in-class and out-of-class experiences persisted despite explicit instruction to only consider in-class experiences. Students seemingly believed the question to be asking how descriptive adding notes was of their activity during notetaking portions of the class period. Students did not seem to consider their notetaking action in the context of the entire class period. Of larger concern, one student justified their response to *add my own content* as: "**I just wanted to change it up, to be honest. Because I read all [questions related to notetaking] as the same… basically the same question.**" This quote is evidence of the larger theme that students seemingly did not differentiate between questions related to constructive engagement, and therefore found the survey repetitive to a confusing degree.

Active

Questions related to active engagement centered around notetaking and example problems. When discussing notetaking *verbatim* or *only the notes the teacher writes down*, students considered either how much of the instructor's notes they copied down, or what portion of their notes were verbatim from what was written on the board. Interpretation varied on the meaning of *the teacher writes down*; some students saw this to include PowerPoint and other means of textually presenting information, while other students saw the question limited to the information physically written by the professor.

When discussing *example problems* and *solution steps*, students agreed that a solution step would involve math, equations, variables, figures and/or a derivation. Students' general perception was if they copied the solution steps verbatim every time a solution was written by the professor, then this item would be *very descriptive* of their in-class behavior. One student explained that *I take verbatim notes* would be *somewhat descriptive* of their in-class activity when, "**Half the notes are verbatim, not half the lecture period is verbatim notes**". This clarifies that students did not consider the lecture period holistically when responding, but the portion of class dedicated to taking notes.

In terms of effectiveness of the learning strategies, students seemed conflicted regarding copying or verbatim notetaking. When presented with example problems, some students saw copying down solution steps as an effective learning strategy. One student justified their actions as:

> **"Sometimes when we were dealing with highlighting equation to solve problems, if I was going to write that equation down, I would definitely write it down verbatim, that way I could reference it later".**

Other students saw example problems requiring them to "**Go look in the book, and see okay, this is the section that came from, and here's the assumptions you have to make that [the professor] might not have mentioned."** Both responses indicated the student's desire to reliably be able to access information to solve similar problems at a future juncture.

Passive

Listening and attentiveness were the foundational behaviors related to passive engagement. When discussing *listening to the lecture without doing anything else*, students presented contrasting viewpoints on the bounds of this question. One student suggested that listening was simply not always the appropriate action: "**I would try to be engaged as possible, but sometimes we would be doing other things, obviously, besides just lecture in that class.**" Listening, as defined by the student, related strictly to lecture. If thinking only of when the lecture occurred, it remains ambiguous if their engagement corresponded to a *very descriptive* response (engaged when lecture was occurring and listening was appropriate), or if the other non-lecture activities shaped their response towards *not at all descriptive* (other activities occur in the course and so listening without doing anything else was not appropriate). In contrast to the prior students, one student saw the same question to mean, "**I'm sitting there and not thinking about other things, I'm not on my phone, I'm not doing whatever**". The "whatever" referenced by the student corresponds to non-course-related activities. This student's interpretation of the question is focused more on course-related versus non-course related content, as opposed to the first student thinking of different actions in response to course content.

Questions surrounding attentiveness saw a range of responses. When prompted with *I focus my attention on things other than course content during lecture,* one student said, "**Whether or not I was distracted during the lecture.**" The student's response view of passive engagement is mild in contrast to the view presented by a student prompted with *I do not pay attention to course content during lecture.* This student saw the question to mean "**checking out completely."** The student is describing a complete lack of engagement rather than passive engagement. A lack of engagement, or a state of unengaged, was not measured explicitly by the scale and emerged as incorporated into passive engagement.

Discussion

The following discussions are based on the results presented above. Here, we aim to bring to light the ways in which students interpreted survey items to inform both the assumptions about engagement presented in the literature and the development of survey items to measure it.

ICAP Framework

Within the ICAP framework presented, four hierarchal modes of engagement are intended to represent increased student learning as they progress towards Interactive engagement. This research has shown that while the hierarchal engagement model may be true in many, or even most, cases, notable exceptions do exist. Students who discussed taking word-for-word notes to ensure that an equation was appropriately depicted would demonstrate the Active mode of engagement. For these students, engagement with a particular equation may require this basic

activity to ensure ongoing learning. In this way, the ICAP framework is limited; while Interactive engagement may frequently be beneficial to learning, it is not always the case.

Seen in the Passive results were students who discussed being not at all engaged in the material. As defined by Wylie and Chi, Passive engagement is "directed towards instruction" [7]. Students did not interpret all Passive questions in this manner. Results point towards an additional mode of engagement not encompassed in the ICAP framework. Students in this additional category are unengaged, or not positioned in any way towards course content.

Out-of-Class Activities

In questions related to all four modes of engagement, students exhibited confusion between the activities taking place in class and those taking place outside of class. The conflation persisted, despite the inclusion of *of my in-class activity* to each response option (e.g. *very descriptive of my in-class activity)*. Students did not appear to draw a distinction between *where* they engaged with course content, rather *how* they engaged with course content. Despite the fact that the course was traditional in nature, meaning students were not regularly expected to take notes outside the classroom, students still did not find the location of activities distinct.

Frequency

The scale provided to students ranged from *not at all descriptive of my in-class activity* to *very descriptive of my in-class activity*. This behavior-based scale targeted understanding the activity of a student as it related to the entire course. Despite this, students talked about their engagement in terms of frequency. Students answered questions based on how they engaged *when* participating in a particular activity (e.g. when taking notes, a student might indicate how often they took them verbatim or added their own content).

Misinterpretation, Fatigue, and Reverse-Coded Questions

Throughout the interviews, there were several instances in which students brought up a failure to read a question correctly, got tired of answering the same questions, or exhibited a stronger response to a question coded in reverse. These results raise concerns related to the length of the survey and the viability of questions coded in reverse. Statistical validation of the survey could be used to limit the number of questions required to understand the mode in which a student engages. Reverse-coded questions have long raised questions in regard to their meaning in scale development [15] and have posed difficulties in other studies measuring student cognitive engagement [9]. Therefore, they must be continually validated throughout survey development to better understand their meaning. The randomization of survey items has been historically used to address order bias and limit its influence over data [16].

Conclusions and Future Work

The purpose of this work is to contribute to the body of knowledge surrounding the measurement of student engagement. Additionally, this work has been poised to have direct and tangible impacts on the ongoing development of the ICCE survey. This survey is in the process of incorporating changes bases upon the results of this work. In new versions, questions have been added to address unengaged students. In an effort to address the lack of distinction of activity by

location, questions have been modified to compare responses to in-class and out-of-class engagement alongside each other. This serves to address future needs of classrooms in which activities outside the classroom mimic traditional in-class actives (e.g. flipped classrooms). The scale has been modified to one of frequency, the most common way in which students understood their engagement.

More work is needed to unpack the questions surrounding the hierarchy of the ICAP framework in engineering. Work evaluating the nature of engagement linked to higher levels of learning in engineering classrooms would provide value feedback to faculty seeking to modify their classrooms. Further work is needed in the realm of survey development to better understand the ways in which students can provide feedback with accuracy.

References

[1]   R. S. Heller, C. Beil, K. Dam, and B. Haerum, "Student and Faculty Perceptions of Engagement in Engineering," *J. Eng. Educ.*, vol. 99, no. 3, pp. 253–261, Jul. 2010.

[2]   K. A. Smith, S. D. Sheppard, D. W. Johnson, and R. T. Johnson, "Pedagogies Of Engagement: Classroom Based Practices," *J. Eng. Educ.*, no. January, pp. 87–101, 2005.

[3]   H. L. Chen, L. R. Lattuca, and E. R. Hamilton, "Conceptualizing Engagement: Contributions of Faculty to Student Engagement in Engineering," *J. Eng. Educ.*, vol. 97, no. 3, pp. 339–353, Jul. 2008.

[4]   S. Freeman *et al.*, "Active Learning Increases Student Performance in Science, Engineering, and Mathematics," *Proc. Natl. Acad. Sci.*, vol. 111, no. 23, pp. 8410–8415, 2014.

[5]   T. J. Nokes-Malach, E. Richey, and S. Gadgil, "When Is It Better to Learn Together? Insights from Research on Collaborative Learning," *Educ Psychol Rev*, vol. 27, 2015.

[6]   J. A. Fredricks, P. C. Blumenfeld, and A. H. Paris, "School Engagement: Potential of the Concept, State of the Evidence," *Source Rev. Educ. Res.*, vol. 74, no. 1, pp. 59–109, 2004.

[7]   M. T. H. Chi and R. Wylie, "The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes," *Educ. Psychol.*, vol. 49, no. 4, pp. 219–243, 2014.

[8]   A. J. Ironside *et al.*, "Incorporating Faculty Sense Making in the Implementation and Modification of an Instrument to Measure Social and Cognitive Engagement." 24-Jun-2017.

[9]   J. J. Appleton, S. L. Christenson, D. Kim, and A. L. Reschly, "Measuring Cognitive and Psychological Engagement: Validation of The Student Engagement Instrument," *J. Sch. Psychol.*, vol. 44, pp. 427–445, 2006.

[10]   J. L. Meece, P. C. Blumenfeld, and R. H. Hoyle, "Students' Goal Orientations and Cognitive Engagement in Classroom Activities," *J. Educ. Psychol.*, vol. 80, no. 4, pp. 514–523, 1988.

[11]   B. Christopher, O. Walker, B. A. Greene, and R. A. Mansell, "Identification with Academics, Intrinsic/Extrinsic Motivation, and Self-Efficacy as Predictors of Cognitive Engagement," *Learn. Individ. Differ.*, vol. 16, 2005.

[12]   J. A. Centra, "Effectiveness of Student Feedback in Modifying College Instruction.," *J. Educ. Psychol.*, vol. 65, no. 3, pp. 395–401, 1973.

[13]   J. Leckey and N. Neill, "Quantifying Quality: The Importance of Student Feedback," *Qual. High. Educ.*, vol. 7, no. 1, pp. 19–32, Apr. 2001.

[14]   S. A. Jacob and S. P. Furgerson, "The Qualitative Report Writing Interview Protocols and

Conducting Interviews: Tips For Students New to the Field of Qualitative Research," *Qual. Rep.*, vol. 17, no. 42, pp. 1–10, 2012.

[15] L. Chang, "Connotatively Consistent and Reversed Connotatively Inconsistent Items are Not Fully Equivalent: Generalizability Study," *Educ. Psychol. Meas.*, vol. 55, no. 6, pp. 991–997, 1995.

[16] W. D. Perreault, "Controlling Order-Effect Bias," *Public Opin. Q.*, vol. 39, no. 4, 1975.