

# Zen and the Art of STEAM: Student Knowledge and Experiences in Interdisciplinary and Traditional Engineering Capstone Experiences

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**Abstract**—This Research Full Paper examines the concept of flow, derived from Zen philosophy and positive psychology, and how interdisciplinary STEAM (science, technology, engineering, arts, and mathematics) and disciplinary electrical engineering students find flow within their coursework and their capstone design experiences. STEAM education incorporates the arts and humanities into the traditional disciplines of STEM. However, students involved in this interdisciplinary space often struggle to find a balance in applying both creative and logical knowledge in their work. The theoretical framework for this study leverages the concept of pure experience from Zen philosophy to analyze flow states in students' interdisciplinary experiences. This theory focuses on the unity of subject/object and rejection of purely logical, positivist thinking for more integrative knowledge acquisition while in flow states. In this secondary analysis, we analyzed interviews conducted with electrical engineering and STEAM students. STEAM students from an interdisciplinary program were found to approach their coursework differently than engineering students, likely because of a difference in assignment guidelines. The engineering students in the study had more restrictive guidelines, while the STEAM students were given more freedom to move between disciplines. Alternatively, students from both disciplines shared many similar values about education and knowledge including the need for enjoyment and personal interest within the coursework as well as finding a balance between logical thought and the desire for creation that a student's program did not determine whether they reached a state of pure experience, or flow, in their work. However, rigid adherence to either the arts or engineering seemed to create disharmony and very few students find cohesion between their values and their approach to knowledge. This paper points to new insights into the design of capstone experiences for STEAM education.

**Keywords**—Capstone projects, student experience, STEAM, Zen, positive psychology

## I. INTRODUCTION

Science, Technology, Engineering, the Arts, and Mathematics (STEAM) education arose in recent years from Science, Technology, Engineering, and Mathematics (STEM) education. STEAM was introduced as a way to help incorporate the arts into education and to emphasize its importance within

schools. The addition of art into traditional STEM was useful for multiple reasons. It helped to broaden students' creativity, which is increasingly becoming an important aspect of assessing candidates for the workforce [1]. Incorporating art into education is also helpful for making students consider issues such as social justice and cultural awareness [2]. The creative thought process is not only useful for the arts as it can help students consider different ways to view problems, or to bridge the gap between the different aspects of STEM [1].

There are multiple articles that focus on STEM students' capstone projects [3], [4], and how students are taught [5]. However, students' experiences in STEAM education are currently understudied. Additional research that focuses on student experiences could help provide insight into better ways to integrate the different elements of STEAM education together. This research can give more clarity into what students are searching for within their coursework and how to create a more inclusive educational experience.

One useful way to analyze student experiences is by using the concept of flow. Flow is a Western concept by Mihaly Csikszentmihalyi that describes a state of optimal experience resulting from deep concentration. In many analyses of learning and student knowledge, Western concepts such as epistemological organization (i.e. absolutism, relativism) and metacognition are used for categorization of students' views and beliefs [5], [6]. Western concepts are more inflexible than those derived from Eastern philosophies such as flow [7]. Concepts such as Zen, mindfulness, or reaching a state of flow rely less on the need for one right answer and more on the way of approaching a problem [8]. While flow is not a strictly Eastern concept, its modern definition can be traced back to Asian philosophers [9], [10]. These philosophies from India, China and Japan are adaptable and possibly better aligned with STEAM education and its analysis. The work from [11] has researched incorporating mindfulness practices into engineering students' education. Applying these ideas to other branches of STEAM may also provide useful insight.

In this paper, we are going to explore STEAM capstone student experiences using this perspective. In particular, we

are going to explore how concepts of flow appear in student experiences and see how flow as an analytic framework helps us develop deeper understandings of STEAM capstone experiences. Our population of STEAM students were sampled from the School of Arts, Media and Engineering (AME) at Arizona State University in a prior study conducted by Cruz et al. [12]. This paper focuses on a secondary analysis of this data by developing understandings of the values of arts, media and engineering (AME) students, as compared to traditional electrical engineering (EE) students at the same university, how AME and EE students experience flow, and how they experience enjoyment during capstone experiences. Both sets of students are required to complete a capstone project in their final year. EE students' projects followed a traditional capstone approach, while AME capstones were more interdisciplinary and incorporated more aspects of STEAM education. Though the details and approaches to the capstone projects were different, studying two sets of students helps us begin to understand the diversity of experiences in more disciplinary and transdisciplinary educational programs.

The research questions this study seeks to answer are:

- 1) To what degree do students appear to reach a state of flow in their capstone experiences?
- 2) What are barriers to reaching flow according to students?
- 3) What values do students have in their approach to learning, and what enjoyment do they derive from these activities?

Answering these questions by centering student experiences and their relation to flow provides unique insights that may otherwise go unnoticed. The literature review provides some background to this field, but also acknowledges existing gaps. The remaining sections describe how this paper intends to bridge these gaps, and provides justification for our findings and their importance.

## II. LITERATURE REVIEW

*a) STEAM:* STEM has been an important aspect of school curricula for the past two decades. In the early 1990s, fear that the US was beginning to fall behind in these areas sparked the evolution of STEM [13]. It was easy to promote STEM to educators and lawmakers, and the term was introduced in 2001 by the National Science Foundation [14]. It paved the way for economic gain and continued innovation. At the same time, arts education faced significant budget cuts in schools and it became harder to convince people that art was important in education [15]. Some educators saw an opportunity to incorporate the arts into STEM, renaming it STEAM education. These educators made the following arguments justifying integrating the arts into STEM: the arts 1) help to connect students to what they are learning, 2) increase creativity, and 3) have a positive effect on standardized test scores [1]. As the economy and job industries fluctuate, employers are no longer simply looking for skilled engineers or mathematicians. Creativity and critical thinking are increasingly important aspects for prospective employees [1]. While some of these arguments are based on the premise that

the arts will help increase economic growth and international competitiveness, others argue vehemently that the arts offer more as they can help us transcend the disciplinary nature inherent in many of our education systems [16], push us towards addressing issues inherent in social justice efforts [2], and promote artistic ways of thinking that include creativity, aesthetic appreciation, spatial reasoning skills, and sensory awareness [17], [18].

By incorporating STEAM into school curricula, students are encouraged to investigate multiple disciplines. They are encouraged to think in both logical and more abstract ways. STEAM education provides students with a more versatile skill set and greater flexibility in thought [1]. However, simply adding the A into the STEM acronym does not mean that the arts will be incorporated meaningfully nor does it mean that integration of these disciplines is without challenges. Finding a balance between the tangible concepts of STEM and the more intangible ones of the arts can be difficult because teachers need help and training to incorporate STEAM effectively [13].

STEAM education encourages flexibility in thought and improves problem-solving skills [19]. However, students can sometimes become too engaged with one discipline and struggle to incorporate the rest. It is important to overcome this barrier so students can develop a more cohesive and holistic view of how each aspect of STEAM works together [20]. This struggle may occur because students feel they are better equipped to understand one discipline than another. This could be because they have spent more time studying it, or it could be because the way a student views knowledge is more amenable to a certain discipline.

We share this history and justification for STEAM education as it provides the context for many of the participants in our study. AME students are in a STEAM program while EE students are in an engineering-specific program (that includes more aspects of STEM). Based on the flexibility of thought and systems thinking that STEAM can offer as discussed above, we expect that AME students may have experiences that are aligned more closely with Eastern philosophies and concepts such as flow. In addition, we feel that the inclusion of STEAM students in our study, our findings can add to our current understanding of the contributions that STEAM educational programs can offer to undergraduate students.

*b) Mindfulness in Engineering Education:* As mentioned in the introduction, there has been some recent work in engineering education focused on the concept of mindfulness [11]. In this work, Huerta discusses the possible benefits of incorporating mindfulness techniques into leadership classes with engineering students. In his dissertation, Huerta demonstrates the effectiveness of mindfulness as it extends beyond the classroom and into students' personal lives. This work demonstrates how useful Eastern philosophies can be within education.

Some of the participants from Huerta's studies mentioned that learning mindfulness techniques such as meditation was useful when they began to feel overwhelmed or anxious in their daily lives (pp. 62-63 of [11]). Students were better

TABLE OF CONCEPTS		
TERM	PROPONENT	DEFINITION
dao	Zhuangzi	a rhythmic way of performing an action that allows a person's spirit to unify and overcome ordinary perception
perceptual train	Nishida Kitaro	the concept of thoughts flowing one into the next so that an uninterrupted stream of consciousness is formed
pure experience	Nishida Kitaro	a state of present, unified conscious, undisturbed by outside or past thoughts and prejudices
flow	Mihaly Csikszentmihalyi	a state of optimal experience brought about by a state of deep concentration; a person's thoughts, feelings, intentions, and senses are all focused on the same goal

Fig. 1. Table of useful concepts in this study from various Asian philosophies

able to separate themselves from negative thought patterns and many found that mindfulness practices helped them develop better focus and organization. Students felt that these practices bled into their perspectives on school, with students reporting being more motivated and productive in completing their assignments. There were a few other educational benefits students associated with incorporating mindfulness practices (pp. 67-70 of [11]). These include students working with their peers or taking leadership roles, students felt they were more confident in taking the lead or expressing their ideas. Additionally, students become better at practicing empathy with others. This allowed members in their group projects to feel appreciated and heard. Huerta's study focuses on the effectiveness of an extracurricular class to cultivate mindfulness. This paper attempts to extend this work through learning how other Eastern-derived philosophies, such as pure experience or flow, are already present within students' approaches to their capstone projects.

### III. THEORETICAL FRAMEWORK

Our theoretical framework is centered around flow, a state of optimal or direct experience which corresponds to individual immersion in performing a task or reaching a goal. We identify a connection between flow and Eastern philosophy, namely various theories and concepts deriving from Zen Buddhism and Daoism. In this section we discuss three key thinkers: Mihaly Csikszentmihalyi, Nishida Kitaro, and Zhuangzi, and how we integrate their works to form a basis for analysis for our study. Then, we describe our motivations for utilizing Eastern philosophy over the conventional, Western analytic philosophies that underlie most education frameworks in STEAM.

Mihaly Csikszentmihalyi is a Western psychologist who authored multiple books on the concept of flow. Csikszentmihalyi describes flow as a way to reach happiness and an inner sense of "togetherness" (pp. 41-42 of Ref. [10]). While happiness might be viewed as an inconsequential factor by some, it is quite integral to the overall concept. Csikszentmihalyi describes this idea in the context of learning, "One might conclude that learning is necessary for happiness, that learning is the pursuit of happiness" [21]. Without a sense of enjoyment in pursuing a goal, people are more reluctant, and less likely

to devote the deep concentration necessary for reaching flow. Additionally, people who routinely find themselves in states of flow are more productive and have found a good balance between challenge and skill (see Figure 2). Flow is defined as a "state of deep concentration [where] consciousness is unusually well ordered. Thoughts, intentions, feelings, and all the senses are focused on the same goal. Experience is in harmony." (Ref. [21]; p.50). Flow is also called optimal experience. An experience where "attention can be freely invested" towards a singular goal (Ref. [21], p.49).

The concepts of harmony and an ordered consciousness are important to flow, and they are derived from multiple Asian schools of thought [22]–[24]. One of the most useful Zen philosophers we utilize is Nishida Kitaro, a 20th-century Japanese philosopher from the Kyoto School who integrated German idealism with Zen Buddhism [25]. He introduced the concepts of pure experience and the perceptual train which we leverage in this study. Nishida Kitaro defines pure experience as "[w]hen one directly experiences one's own state of consciousness, there is not yet a subject or an object, and knowing and its object are completely unified." ([22], p.3-4). Pure experience can also be described as a moment when a person's thoughts are so completely absorbed in the present task that they do not have room for outside judgments or past knowledge. The experience is solely present-focused, which relates to Nishida's second concept, the perceptual train. The perceptual train is a constant, uninterrupted stream of thought, in which a person is focused from one present moment to the next. He compares this idea to the performance of a musician or a dancer who has practiced a piece so thoroughly that it flows through their mind effortlessly.

The final thinker that we rely on for this framework is Zhuangzi, the believed author of a set of short stories referred to as The Inner Chapters. Zhuangzi is important because his writings help form a bridge between the concepts of Csikszentmihalyi and those of Nishida. Some of the Inner Chapters give short anecdotes of how certain characters can achieve flow (or *dao*, as it is called in the Inner Chapters). They emphasize a sense of unity between the subject and object as Nishida does. But, they also describe the relationship between skill and challenge that Csikszentmihalyi discusses, that seems absent from the Nishida works we have referenced.

As mentioned in the introduction, Western philosophy has been the theoretical foundation for studying students in STEAM disciplines, in part due to the educational researchers from primarily Western countries who advocated for STEAM [13]. This shared philosophical viewpoint often includes categorizing students into epistemological camps as well as analyzing creativity in these spaces as value-added to traditional knowledge. However, using Western epistemologies creates an implicit division between the student and their coursework. Indeed, Cruz et al. noticed that students in a STEAM setting typically switched epistemologies for different projects [12], and other works in epistemology have pointed to the need for flexibility in categories [26].

Philosophically, several of these theoretical difficulties can

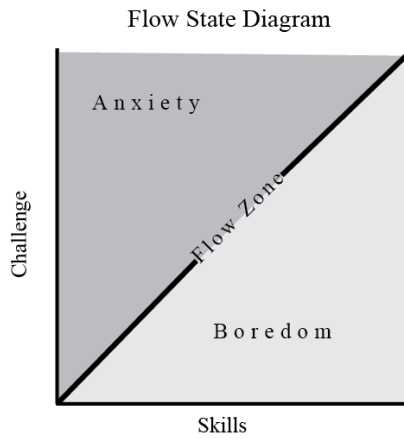


Fig. 2. A diagram illustrating the concept of flow and its relationship to challenge and skills utilized in a particular activity [10].

be tied to the divide between subject and object (also known as subject/object ontology) that is centered in Western thought. Nishida discusses how this divide must be dissolved in order to reach a state of pure experience. This concept is useful to apply to students in STEAM because the discipline is meant to break down barriers between areas of knowledge [26]. Using the Eastern concepts of Zen and flow to define a framework for analysis supports the variety and complexity of experiences in STEAM. Zen centers on a sense of oneness and interconnectedness between a person and their outside experiences. STEAM education can help facilitate this as students are being taught how to view disciplines outside their normal boundaries and see how they can connect, they might be better equipped to reach states of flow.

Within this study, the conditions for indicating the presence of flow include (1) how much alignment there is between a student's values and the values present in their coursework (which can indicate how much order, or disorder, is present in a student's consciousness), and (2) How much enjoyment students find in their coursework. These conditions helped inform our research design and secondary data analysis to find examples of flow in student experiences.

#### IV. RESEARCH DESIGN

**Participants and Data Collection:** This paper is based on secondary data analysis of existing interview data shared by the authors of [12], and was approved for study under IRB. This study was conducted at Arizona State University across the School of Arts, Media and Engineering and the School of Electrical, Computer and Energy Engineering. Each student was originally interviewed using a semi-structured interview protocol designed to question their views on knowledge and learning for capstone experiences. While secondary analysis is limited since it cannot change the interview questions or collect new data, flow had emerged in preliminary analysis and the research team felt that this data could be analyzed through a new lens focusing on the emergent themes of

flow and its process/integration in students' coursework. The participants were undergraduate students in their junior or senior years who were enrolled in a senior capstone course. Five of these students belonged to the interdisciplinary media arts (AME) program, and four of them were in an EE capstone. Student demographics that were self-reported by participants included seven female and two male participants, as well as race/ethnicities including White (3), Hispanic or Latino (3), Native American (1), and Multiracial (2).

**Data Analysis:** Each interview went through two cycles of coding [27]. The first cycle used a combination of in-vivo and open coding and focused on student experiences, and how students viewed creativity. The first cycle of coding produced lengthy and specific codes (e.g., *Enjoyment of something as a gateway for knowledge; engineering knowledge breeds more creativity because students can do what they want.*) Codes from the first cycle were then shortened to see if they could provide better insight during subsequent coding cycles.

The interviews were then coded a second time using values coding. Values coding is a useful way to interpret students' perspectives, beliefs, and attitudes about knowledge, creativity, and project work. After coding the interviews, a diagram was created for each student that included their values, attitudes, and beliefs. These codes were then categorized into three main "core values" or values that seemed integral to the students' views on knowledge and experience. An example diagram is visualized in Figure 3. These diagrams were further analyzed by considering the integration or connection students had between their respective core value categories, which was represented by connecting threads between codes in the diagram. The amount of connectivity roughly correlated to the level of flow present in the particular student as we discuss in the Findings and Discussion section. During the analysis process, memos were written by the first author to reflect on student experiences, and what seemed to help, or hinder, their ability to find flow. Memos were also useful for keeping track of emerging themes, alignment to the theoretical framework, and reflecting on researcher positionality. Towards the end of the analysis process, quotations from student interviews were selected and connected to key ideas from our theoretical framework. This is elaborated on in the Findings and Discussion section.

**Positionality:** The researchers involved in this process all have different expectations and biases that they bring to the table when performing this qualitative research. The first author is currently a student in the AME program similar to some of the students who were interviewed. They have an explicit interest in the arts and had to release their bias towards art students and the belief that they would be more likely to achieve flow. The process of writing memos allowed the first author to restructure their initial ideas, and develop a broader definition of flow. The second author is a faculty member with expertise in engineering education and qualitative research, and the third author is a joint faculty in AME and Electrical Engineering. The researchers had a strong prior interest in Eastern philosophy, particularly in Zen and ideas of flow which

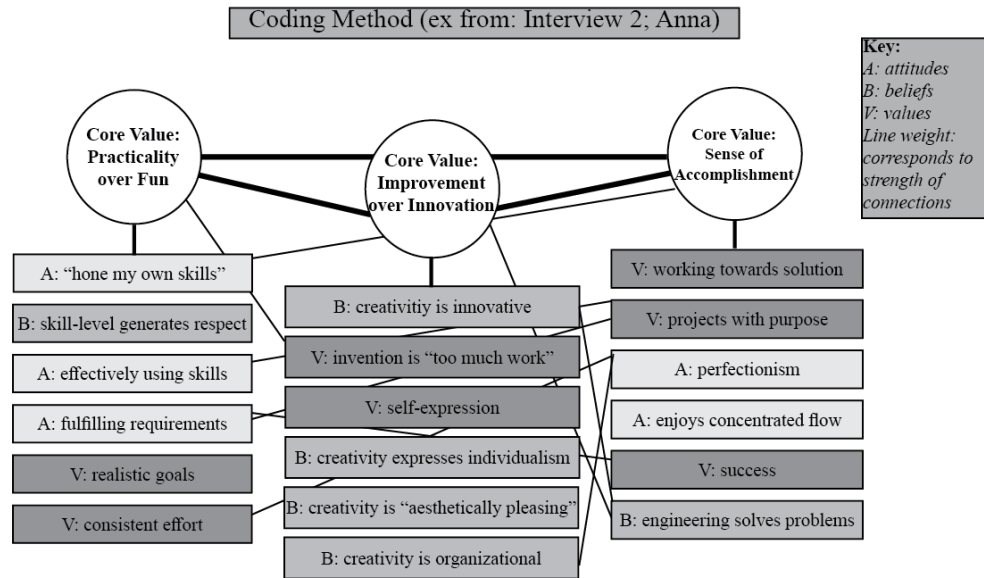


Fig. 3. Example of a coding diagram generated as part of our analysis methods.

influenced the topic of interest in this paper.

## V. FINDINGS AND DISCUSSION

Our findings highlight individual students and their experiences being categorized into either high or low-flow states. Students were not grouped by major or discipline, as it was seen throughout the analysis process that students from both programs could reach a state of flow. The categories of high-flow or low-flow are purposefully indistinct and broad, which can be applied to many different activities as evidenced by the following paragraphs detailing student experiences. Quotations from student interviews help provide more evidence and insight into students' thought processes while in these flow states. Connecting these quotes to prominent ideas derived from our theoretical framework helps to discuss both the identification of flow states and the conditions in which these states emerge in the data. The final part of this section provides some comparison between students who experience higher flow states with those who experience lower flow states, thus summarizing the barriers students may face when completing their coursework.

### A. High-Flow Students

Students who demonstrated reaching a high level of flow have a few themes in common. There is a sense of unity between their values and their coursework. Beyond this alignment, students integrated their core values so that they could

move from one aspect of learning to the next without interruption. These students also found enjoyment in all areas of their coursework, instead of over-identifying with one discipline.

Andres identified himself as an artist because of his interest in music. Once he transferred into the AME program, however, he recognized the possibilities of engineering and came to realize that he "could do all this like engineering and computer stuff to make art." Instead of viewing engineering as a barrier to his artistic process, he sees it as being a bridge between the two disciplines, recognizing the need for balance. And in STEAM, balance does not always involve sacrificing the artistic aspect of a project for the technical. Sometimes it implies just the opposite. He describes his final project and how "the code was kind of fudged a little bit so that [the music] could sound prettier." Andres also mentions that "fudging" the code removed "the truth" behind the engineering aspect a bit. But this seems to be part of maintaining the balance between disciplines.

Nishida Kitaro might have a different perspective on what truth means. In Nishida's work, *An Inquiry into the Good*, he writes:

*"Viewed in this way, truth is identical with a desire that matches the facts and can be actualized. The distinction is simply that the former is universal whereas the latter is individual. The fulfillment of the will or the culmination of truth thus means that from a state of disunity, one has arrived at the state of pure experience."* (Ref. [22]; p.26)

Nishida's definition of truth has nothing to do with technical or logical accuracy. Coding accuracy is likely what Andres was referring to when he said that the truth of his code was removed from his final project. However, his project is aligned more with Nishida's concept of truth than he might think. His individual "desire" was that the musical aspect of his project would sound better. The "facts" are the particular engineering workarounds that evoked Andres' specific artistic goals, even though they do not satisfy traditional or logical constraints for this code. This is Andres' personal "culmination of truth." And once that happens, according to Nishida, one has reached a state of pure experience. Pure experience involves distancing oneself from outside judgments and past beliefs. This allows a person to be wholly involved, or unified, with the subject at hand. Andres has found unity between himself and his project by not allowing preconceived notions of what truth means in coding prevent him from applying his musical aptitude.

Another student shares this same sentiment of balance. Molly is a student in the EE program, but she double majors in engineering and studio art. Throughout her interview, Molly talks about many of her projects that incorporate engineering and art into a cohesive whole. Molly says that she "likes to bring engineering into [her art projects]." Unlike the last student Andres, she does not view engineering as a bridge towards art, but she does see how engineering can be creative in the same way that art is. The boundaries between engineering and art for Molly are so dissolved that when she is asked how different the approach to an art project would be to an engineering one, she seems confused and says "I don't really see how they would be any different."

Molly's response is striking, and is reminiscent of a short story from Zhuangzi's Inner Chapters:

*"Cook Ding was carving an ox carcass for Lord Wenhui. With each touch of his hand, heave of his shoulder, step of his feet, thrust of his knee – whop! whish! – he wielded his knife with a whoosh, and every move was in rhythm. It was as though he were performing the Dance of the Mulberry Grove or keeping to the beat of the Constant Source music.*

*"Ah, marvelous!" said Lord Wenhui. "Surely this is the acme of skill!"*

*Cook Ding laid down his knife and replied, "What your servant loves, my lord, is the Dao, and that is a step beyond skill.*

*"At the beginning, when I first began carving up oxen, all I could see was the whole carcass. After three years I could no longer see the carcass whole, and now I meet it with my spirit and don't look with my eyes. Perception and understanding cease and spirit moves as it will." (Ref. [24], pp.27-28)*

This passage, while seemingly antiquated and ambiguous, actually connects the attitudes of both Molly and Cook Ding. Cook Ding sees no separation between the act of carving and himself, or his spirit. However, the cook recognizes that skill is an important precursor to reaching that state of unity. If we place Molly in the position of Cook Ding, her "carving" could be compared to engineering, while her "spirit" could be her love of art. They have coalesced together in such a way

that it is easy for Molly to find her Dao, or flow, between the two disciplines. It was also important for Molly to build her skills in both disciplines to reach this state of flow. Her double-majoring, experimenting, and creative projects have all helped in that regard.

The previous two examples demonstrate how viewing different disciplines as opportunities instead of obstacles is conducive to flow. Unity of the environment (e.g. through structural interdisciplinarity) is one aspect of flow, but unity of values is also important. Anna is an EE student who demonstrates this concept well. Unlike the previous two students, Anna does not view herself as an artist in any capacity. She mainly likes "having kind of a purpose, some point that [she's] driving towards." Engineering and its technical core fill this desire for her.

One place Anna describes finding flow is through solving math problems. She describes completing "crazy, written-out, four-page long" problems as being something she enjoys and she values the sense of accomplishment. She says "solving to an answer... it's so satisfying for me." This passion is indicative of a student in a high-flow state. In Csikszentmihalyi's book on flow, he writes, "*Solving mental puzzles is one of the oldest forms of enjoyable activity, the precursor of philosophy and modern science.*" ([10], pp. 126) For Anna, mathematics can be considered a type of mental puzzle, enjoyable for the critical thinking needed.

Some people might believe that being in a state of flow would require a person to be disconnected from thought and completely absorbed in whatever activity they are doing. This would disqualify Anna's math solving as a flow state. However, Nishida believes otherwise:

*"If pure experience were simple or passive it would be opposed to thinking. But if pure experience means to know things just as they are, then simplicity or passivity is not characteristics of it-the truly direct state is constitutive and active." (Ref. [22]; p.17)*

Mathematics and other mental puzzles require active use of the mind. It requires good thinking. And, to reach such a state of flow as Anna describes, it requires a certain intrinsic knowledge of mathematics. Understanding the formulas and processes that are necessary fits the definition of knowing "things just as they are." Also, because Anna says reaching an answer is "so satisfying" for her, it can be reasoned that the other requirement for flow, enjoyment, has been met.

## B. Lower States of Flow

Many students struggle with accomplishing the same level of integration and enjoyment as the students described in the previous section. At times, being an artist or humanities student within a STEAM program can be a disadvantage, as the next two students have not found a successful way to incorporate their artistic knowledge with the engineering aspect of the discipline.

Raquelle strictly identifies herself as an artist. She says "ever since I'm a little girl I always said 'art, art, art.'" While Raquelle's initial statement mirrors that of the musician



Andres earlier, she has more of an issue with viewing engineering as an obstacle. In her opinion, art is liberating, while engineering is restrictive. Engineering is also intimidating because Raquelle views most other students as simply being “better” than she is. While Raquelle loves art, there is a disconnect between her creative values and her values for stability. She chose to enter the AME program not out of explicit interest, but because she needed to “be realistic.” Raquelle wants “to get into a field where at least someone gives [her] a job.” In her view, art does not offer this economic or professional stability. This causes her to feel like she has to sacrifice her artistic values in favor of another, leading to a lack of enjoyment in her studies and making flow nearly impossible to achieve.

To analyze the struggle Raquelle is going through, we turn to a Zen koan, or short paradoxical anecdote or riddle. The koan reads:

*“Nan-in, a Japanese master during the Meiji era, received a university professor who came to inquire about Zen. Nan-in served tea. He poured his visitor’s cup full and then kept on pouring. The professor watched the overflow until he no longer could restrain himself. ‘It is overfull. No more will go in!’ ‘Like this cup,’ Nan-in said, ‘you are full of your own opinions and speculations. How can I show you Zen unless you first empty your cup?’” (101 Zen Stones, n.d.).*

This koan exemplifies the lesson of separating the ego from the mind. The master does not mean that the professor can never learn anything new; he only means that the professor must release his attachment to previously held ideas. The same can be said about Raquelle. She said she is intimidated to learn engineering because she believes the other engineering students are more advanced than she is. An example of the “opinions and speculations” the Zen master warned against. These speculations are self-limiting beliefs, which stem from the ego. Raquelle also mentions that “[she’s] not going to change who [she is],” and she views herself only as an artist. This is another example of the ego, and the attachment she has to her identity. Raquelle’s cup is already overfull with her restrictive beliefs. If she truly wants to learn engineering, she must first “empty her cup,” which means discarding the ideas that she is inadequate to understand engineering, and that her only identity is that of an artist. If she does not release these ideas, she will leave no room for new information, which might conflict with her previous beliefs.

Another AME student Helen also faces barriers to flow for similar reasons. Helen also identifies as a more creative person but she does not view engineering as restrictive. Similar to the high-flow students above, Helen views it as a method to achieve greater creative output. The issue she encounters is a disconnect between her skills and what she wants to accomplish. Helen discusses the art projects she envisions but laments that “it takes a much higher level of skill to get to that point where you can intuitively ... know what options are available that are also considered correct options.”

Most of the EE students that were surveyed felt accomplished in what they do, and many do not have the same issues

with clashing values as the more artistic students, who always seem to feel that they have to choose between engineering and art. However, the barriers that prevent engineering students from achieving flow are still present albeit more subtle. Their values are always broken into distinctive fragments that prevent integration. Because of this, there is usually one value that takes precedence over another leading to imbalances.

One engineering student, Steven, exemplifies this struggle of values. Steven values work ethic and perseverance. He describes himself as “task-oriented” and as someone with an “execution mindset.” While he values work ethic, his capstone project dampens his usual resolve. He says that the project “...is one thing I feel like I have to do and I’m not necessarily going to put too much mental effort into it.” He also laments that his “task was too well described” and leaves only a “finite space of creativity.” This is unfortunate for Steven because he also enjoys creativity and has a novel approach to it. He believes that “science is art” and the start of any kind of invention or discovery is creativity.

Steven’s problems can be echoed by the work of Csikszentmihalyi: “If a person feels coerced to read a certain book, to follow a given course because that is supposed to be the way to do it, learning will go against the grain. But if the decision is to take that same route because of an inner feeling of rightness, the learning will be relatively effortless and enjoyable.” (Ref. [10], pp. 148)

If Steven’s project had looser requirements or allowed for a more open-ended approach he would be able to find the enjoyment Csikszentmihalyi mentions. It would allow him to combine his appreciation for creativity and discovery with his value of work ethic. Steven would find his own route for learning, instead of feeling pressured to stay on the one already planned out for him, which leaves him feeling confined.

Other students experience some of these same problems but to a lesser degree. Rachel and Sarah, two AME students with engineering experience, are not able to achieve high states of flow even though both students enjoy their coursework. Rachel, for example, switched from electrical engineering to the AME school, where she appreciates the “creative freedom” she is allowed to have. She also values fun in learning, to prevent it from becoming a “chore.” Sarah appreciates the “creative side of [coursework], but also the functionality.” While both students enjoy being creative, there is a larger emphasis on simply accommodating different values and interests rather than integration between them. Sarah says, “it’s become more clear to me that I’m ... starting to find a balance within how to use things and how to also work that into the arts.” The emphasis here is on the word “starting.” Sarah still views both art and engineering as two distinct disciplines, rather than seeing how they can both work together.

This disqualifies both students from reaching a state of flow because accommodation does not indicate unity. While they are closer to flow than some of their counterparts, their values do not inform one another. If both students are constantly caught between two disciplines, then their consciousness will always be split in two directions. This idea is reflected in a

statement from Nishida's *An Inquiry into the Good*:

*"What we usually refer to as experience is adulterated with some form of thought, so by pure I am referring to the state of experience just as it is without the least addition of deliberative discrimination."* ([22]; p. 3)

These students face constant deliberation within their coursework experiences. Both have to make a conscious choice over which discipline is sufficiently represented or needs more attention. Whereas, if both students could find a way to weave their technical skills and their creative skills together within their projects, they would fit the criteria both Csikszentmihalyi and Nishida indicate for reaching a state of flow.

### C. Comparison Across Cases: Barriers to Flow

By looking at these students who experience lower states of flow, we can summarize some of the main barriers to achieving flow. Identifying strongly as an artist or engineer could be self-limiting as exemplified by the art student, Raquelle, and the engineering student, Steven. Raquelle clings tightly to her artist identity but feels she is not allowed to fully express it. Steven appreciates his work ethic, which is why he continues to work on his capstone project even though he does not enjoy it and it blocks any higher state of flow in this project. Helen is isolated in the barriers she faces to flow. She understands that the distinctions between art and engineering do not prevent them from working together. Helen's issue is that her current repertoire of skills does not allow her to execute the creative projects she wants to. This is in clear contrast to the student in the high flow section above, Molly, who is skilled in both engineering and studio art, and feels no barriers to flow.

The former engineers who transferred into AME, Rachel, and Sarah, are not as limited as some other students. They appreciate the relationship between the disciplines of art and engineering. However, these two students fall short of integration between values and disciplines. The engineer, Anna, does not face these AME struggles because creativity is not something she feels the need to integrate. All of her values fall on the more positivistic, engineering-focused spectrum.

## VI. IMPLICATIONS AND CONCLUSION

This research suggests that there are some differences in how Arts, Media and Engineering (AME) and Electrical Engineering (EE) students approach their coursework. However, this is due to the nature and structure of the two programs rather than inherent differences between the two sets of students. AME students are allowed an aspect of freedom within their coursework because the program works with a broad range of disciplines. Students are encouraged to create projects that are both artistic and technical, that require both logical and creative thought. AME students are also encouraged to conceive their original project ideas. EE students were not allowed this freedom. Creativity is not encouraged within the program, as exemplified by the structure of their capstone projects. Students are allowed to choose their final project, but then they must strictly adhere to the project requirements.

While students in the AME and EE programs are required to approach projects differently, students within both programs seem to have many similar values in education. One value that was very common among students was the need for fun or enjoyment in learning. Students tend to value enjoyment because it keeps them interested in the topic at hand, engaged, and helps them retain information better. Many students also tended to value creative freedom or individuality. While the AME program seems better suited to fulfill this need, some students still struggle with finding ways for their coursework to match their values. Art-leaning students in particular seem to face this tension. This is largely due to the fact that artistic skill is not easily transferable into engineering skill. Many art students found themselves with expansive, creative ideas that they were unable to execute due to lack of engineering knowledge. This caused them to have to sacrifice some of their creativity in favor of a simpler project or idea.

For students in both programs, it can be assumed that reaching a sense of unity between their values and the coursework they undertake would be ideal. Students who achieve this unity are better able to reach a state of flow within their education. Flow involves a combination of enjoyment, challenge, and skill that students can harness throughout their coursework. Students who find disunity between their values and coursework face the opposite consequence. They face a disproportionate amount of challenges (either too much or too little, usually the former), and often feel their skills and talents are being wasted, finding it difficult to reach a flow experience.

Students from either program can face obstacles to flow that render it unlikely for them to achieve it. However, students in either program can also find it relatively easy to achieve flow. This ability to achieve flow is not related so much to the course of study, but how well students can see their values reflected in their chosen program.

The implications for this study could influence the way schools structure their capstone projects, especially for interdisciplinary investigations. Students who find flow in their projects enjoy their final projects more and they are more motivated to complete them. This should be the goal of more schools within their capstone projects. As seen with the students facing barriers to flow, they are less motivated in their work, they do not enjoy their final projects, and may think of themselves as inadequate. We think the concept of flow, and how it can be beneficial in such student experiences warrants further investigation, particularly in how to set up environments conducive to fostering flow in students.

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