

# Student-mentor views on inquiry-based learning : A challenge for designing effective inquiry-based classes with mentors

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**This innovative practice work-in-progress paper presents a study on the relation between student-mentors' engagement in the inquiry cycle with their practice of inquiry. Since every student has a personal style and way of inquiry, an assessment of the student-mentors' definition of inquiry was performed through personal interviews, reflections, and periodic observations and discussions. The findings of this study show that reflective practices help in development of deeper thought and connected learning for students. Furthermore, factors such as maturity in the program, personal belief in the inquiry process, affinity to inspiring students, etc. all contribute to student-mentors' growth in inquiry-based learning environments.**

***Index Terms*—Student-mentors, Inquiry-base, Reflection, Freshmen engineering**

## I. INTRODUCTION

THE inquiry process relies on the basic curiosity of the inquirer or learner [1]–[3]. While personal curiosity can go a long way, it is challenging to assess or educate students on the basis of this personalized parameter [4]–[7]. University education presents an additional challenge in its reliance on condensing large amounts of relevant information into meaningful content for students [8]. This kind of a practice can create an information overload that reduces students interest and ability to take part in the inquiry process. In these environments, students become superficial learners and rarely have the freedom to think, question or reason through all of the concepts that might fuel their curiosity [9], [10]. To study the feasibility of inquiry practices in such curriculums, in this work, the verbalization, perception and practice of Deweyan inquiry [11] process for a select group of students (student-mentors) is studied and evaluated.

### A. Framework

The process of inquiry adapted in our courses is designed according to the philosophical perspectives that were initiated with John Dewey's theory of inquiry [12], [13]. Dewey's method is aligned with the scientific method that begins with forming a hypothesis and questioning all aspects to prove or disprove the question and the findings [14]–[16]. The five steps of thought as described by Dewey include [12], [14]:

1. A felt difficulty
2. Locating and defining the difficulty
3. Suggestion of possible solutions

4. Ideation and development based on reasoning of possible solutions (Reflecting and understanding the bearings (implications) of the suggestions)
5. Observations and experimentation to be able to reason the acceptance or rejection of the idea (Resulting in conclusion that is connected to belief's and disbelief's)

One of our freshman engineering courses, designed around inquiry-based learning, requires students to think critically, ask questions, reflect, and engage in different cycles of inquiry [12]. In the course, students learn to engage in cyclical processes of questioning and reflecting. Through reflection, each student is asked to develop questions based on the concepts that they consider to be important. Such a cyclic process lets students review, re-examine, and re-connect their learning with their experiences. Thereafter, the goal of the course is for students to remain constantly engaged in a quest of learning and thinking. The course also shows students that when they learn something new, they move through three stages of cognitive development. The first stage is a theoretical/technical stage, where their knowledge comes from what they were told, students mimic the process that they have heard. Then the students move into a practical stage where they start doing things on their own, make mistakes, ask questions and learn through the process. Finally, they reach the emancipatory stage, where, upon examination of different aspects of the problems/solutions and questions and answers, they unite different parts of their knowledge. This helps students make a connected story that enables them to face and solve related problems more effectively. These learning stages are according to Heabermass and Grundy's [17] cognitive development stages and aligned with Whitehead's [18] ideas on cyclic theory of learning.

## II. STUDENT-MENTORS

Mentoring is often considered to be a complementary relationship between a more experienced and knowledgeable individual and an apprentice or new enthusiastic member with hope and energy to make a difference in everyone's life [19], [20]. In many instances, personal styles, experiences, and perceptions enrich the mentoring process and response of the mentees [21]–[23]. In our study, students who demonstrated an affinity for engagement in inquiry-based practices were selected at the beginning of the sophomore year in the program. They were invited to become further involved in the process of mentoring and helping the facilitators team

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(the instruction and course management team). In the initial term, these students are “observers” to other advanced student-mentors, learning from their styles and methods. Besides lab and lectures, the student-mentors are also involved in a weekly discussions on mentoring, on how the process of inquiry fits into the class and lab, and on what role the student-mentors play for the students. Students in the inquiry-based course are led in the labs by student-mentors who were first initiated in the process of inquiry as students within the very same freshmen engineering course. Once they join the mentor program, the student-mentors re-examine the cycle of inquiry, improve their approach to the three stages of learning [17], [24] and correspondingly lead the students through the same stages.

Beyond the course and mentoring, the student-mentors are also trained in the course objectives. They understand and have practiced the cycles of inquiry since they took the class and have gained understanding through the mentor training sessions. However, student-mentors, like everyone else, learn and practice the inquiry process in their own ways. Our understanding of student-mentors is that they have a deeper connection with their cycles of inquiry through their regular challenges as students and additional responsibility of mentoring freshman students through their learning cycles. This is emphasized in mentor meetings that contain discussions about understanding and examining the objectives of the course. The mentor meetings also focus on group activities that allow everyone to have a better understanding of the student-mentors’ roles and responsibilities in the classroom and their cycles of inquiry and critical thinking. It is expected that since mentors have more experience and familiarity in the process of inquiry they can facilitate students’ inquiries, discoveries and growth. Through this work, we seek to understand if the process of facilitating students’ inquiry helps student-mentors deepen their personal thinking process and grow in the inquiry cycle.

### III. ROLE OF STUDENT-MENTORS

The student-mentors will be using the inquiry approach to facilitate the students’ journey through the three stages of learning. While most students do not necessarily move into the emancipatory stage to make a better and overall connection of their knowledge, they can start their journey in that direction and have reasonable gains in some of their more passionate efforts. The mentor’s role is to use the Grundy and Heabermass framework to facilitate students to make better connections, and reach the third stage of cognitive development. They also make developments through the cycle and will reach the third stage gradually through practice.

Historically, student-mentoring was introduced in our department through the inception of our new inquiry-based freshman engineering class. The student-mentor is designated the role of a facilitator in the students learning community. Student-mentors are expected to be different than teaching assistants (TA). Teaching assistants are commonly thought of as another instructor for the class. They may typically not have much interest in their students on a personal level and instead only interact with students in the class when their

assistance is requested by the students. In contrast, student-mentors may fulfill some of the duties of a teaching assistant, such as grading, but they will also belong to the community of learners. They are expected to form empathetic bonds with students in order to get to know them and encourage the students to learn, grow, and think independently. The student-mentor plays the role of a facilitator, growing in the process themselves by learning from varied perspectives and situations.

In our course this model of student-mentoring is adopted and further enriched by tailoring the mentoring process around Dewey’s process of inquiry. The main difference between the student-mentors and TAs is that there is assumed expectation from TAs in engineering classes. TAs are expected (mostly by the students) to help students do the lab’s and assignment’s, they are also assumed to answer questions. Whereas, a student-mentors role is to facilitate the students learning, inquiry, and journey, and to be supportive by knowing the students and being able to help lead students through their journey through learning. The student-mentors may decide to answer some questions directly, if they identify the students state to need an immediate answer. But they will continue to help students in defining, and making meaningful progress in their learning process. There are some great educators who understand the journey students take and how students value a journey that is true to themselves. They become facilitators in the students’ growth and learning.

### IV. STUDENT-MENTORS AND THE INQUIRY PROCESS

The inquiry process impressed upon the students and the mentors is as discussed in I-A.

While the students go through the process of inquiry in the course and the lab, the student-mentors face the task of understanding a student’s stage in the process through the student’s questions, discussions, and reflections. The student-mentors then need to navigate with the students in the cycle, seeing things from the student’s view and preventing their personal beliefs and perspective from interfering with the student’s learning and growth process. This is not easy for the student-mentors, since the students demand easy answers and the student-mentors are often in a position where they are forced to provide quick answers instead of inspiring them further into inquiry.

To further understand the student-mentor’s involvement in the cycle of inquiry, we first examine their personal experiences. The student-mentor experiences include their own learning cycles, classes, and mentoring of students. The student-mentors are asked to talk and share their own verbalization of how they approach the cycle and how they gauge students’ inquiry. These interpretations vary with the academic maturity of student-mentors within the undergraduate program. It also depends on their relationship with the students and their awareness and reason for being in the cycle of inquiry. It is observed that often when student-mentors are too busy with demanding courses (there are many of these courses in typical engineering curriculum), they are sometimes unable to achieve in-depth engagement in personal reflective cycles nor would they be able to inspire students to be creative. Such challenges will also be discussed in the upcoming section.

### A. Student-Mentor Expectations

Student-mentors are expected to initiate and facilitate formation of a community of learners with the students and their peers. They are forever involved in the process of learning, asking meaningful questions and growing in the cycle of inquiry. Being team players, the student-mentors are expected to know the community, find what the community needs and make meaningful teams and connections to facilitate learning, problem solving and critical thinking. The student-mentors also need to listen, be a part of the community, know each other and the students and challenge the community for collective growth. They are the leaders and collaborators of the team.

## V. STUDENT-MENTOR REFLECTIONS

Since all of the student-mentors have been through the freshman inquiry-based class, our first study was designed around understanding how and when they entered the cycle of inquiry, first as students and then as student-mentors. The student-mentors reflected on how they entered the cycle of inquiry in daily situations with students and how the process of inquiry was useful for them in becoming better students and consequently better student-mentors. Their reflections were further studied based on the student-mentor's association (number of years) with the mentor program. Three mentor levels were defined: Beginner, Intermediate, and Advanced. Academically, the student-mentors were either in their sophomore, junior, or senior year. In our analysis, keywords and common phrases from the student-mentors reflections have been presented. Since our analysis was designed around reflections, initially, it was expected that beginner student-mentors would have short and not necessarily in-depth reflections due to limited exposure to the inquiry process and advanced student-mentors would be deeper and more detailed. However, it was observed that the length of reflections did not depend on their academic maturity within the program, but the depth and thematic content of the reflections did.

Our analysis of the impact of the inquiry process on the student-mentor's growth is dependent on a few different reflections. First, we evaluate how student-mentors verbalize their own paths within the cycle of inquiry. Next, we evaluate how the student-mentors personally interpret their verbalization of the cycle and how they use it as student-mentors. Then, we evaluate their practice of the process of inquiry in student interactions. Lastly, we present the perception of student-mentors via the students and vice versa. It is expected that through the evaluation of these reflections we can track the student-mentor's growth and the trajectory of their inquiry.

### A. Verbalization of inquiry

The student-mentors were asked: "*When are you in the cycle of inquiry? What do you do when you are in the cycle? When do you exit the cycle?*"

A summary of the student-mentors responses may be seen in Table I. In each mentorship level we observe that the student-mentors' engagement with the cycle of inquiry becomes deeper, more personalized, and more introspective. The

process of approaching a given problem or felt difficulty changes with maturity in the academic and mentorship program. Nonetheless, a direct correlation may not exist between a student's academic maturity and maturity as a student-mentor and this may be investigated in detail in future works.

### B. Impact of inquiry-cycle awareness on mentorship

Once the student-mentors had verbalized their paths within the cycle of inquiry, they were asked: "*Did the inquiry process help them grow as students and learners? How did they verbalize their personal inquiry process and its importance for working with students?*" They were also asked if the process of inquiry affected them and made them better student-mentors for students. Table II is a short summary of the student-mentor's key responses classified based on their level within the mentorship.

### C. Practice of inquiry with students

The student-mentors were also asked to discuss how they would go about working with students in certain situations in the lab. The student-mentors reflected on how they asked questions to gain a better understanding of the student's question and location in the inquiry process. A short summary of how student-mentors phrase their use of inquiry to create a better learning environment is found in Table III.

### D. Perception of students by student-mentors and vice versa

In the labs, the students were asked to explain their perception of the student-mentor's presence. "*Did they consider it to be helpful, an interference or a resource?*"

Based on the student's feedback we found that most students from the initial freshmen labs considered the presence of mentors to be helpful and guiding, while others appreciated their presence or considered it to be essential. Some students stated that they were glad that the student-mentors didn't directly show them the answer but showed them the process via subtle hints, or pushed them along a path where they could think about their questions and reach an answer. A few students stated that their curiosity was killed if they just listened to someone speak without further interactions. A group of students mentioned that they perceived the student-mentors as essential resources within the program, that they were approachable, and had a greater familiarity with the program. Additionally, students in advanced freshman labs saw the student-mentors as an invaluable resource for brainstorming ideas, developing insights about labs and classes, and giving suggestions or otherwise helping with projects.

Student interactions had a far deeper impact on the student-mentors. Student-mentors stated thinking about their conversations long after they were over. They also started thinking about their responses to student's questions and their own concerns. They found it extremely rewarding to be able to see new perspectives from the student's eyes. Some felt inspired by students to explore more and engage in more challenging projects. Others felt they could better connect their thinking and ideas with the constant challenge and questions from the students. In essence the cyclic process of inquiry allowed student-mentors to find an avenue of expressing their ideas and connecting their learning through the questions posed by students.

Level of Mentorship	When are you in the cycle?	What do you do in the cycle?	When do you exit the cycle?
<b>Beginner</b>	Curious to figure out Stuck and frustrated	Deeper thinking, resources, more than problem solving Approach different sources to figure out inquiry	On finding a solution and feeling content with efforts Accept results/process
<b>Intermediate</b>	Meaningful engagement in reflection Question and think about the problem	Communicate with others and stay away from the problem to reflect Personal introspection and reflection	Multiple cycles at once, some resolve faster than others Never exit, live and keep going in the cycle
<b>Advanced</b>	Personal assumptions are challenged	Explore multiple different paths of thought to find a destination	Discomfort is removed by formation and further examination of belief's/disbelief's

TABLE I: Student-mentors verbalization of inquiry

Level of Mentorship	Personal inquiry cycle	Inquiry as a mentor
<b>Beginner</b>	Deeper and meaningful thinking Identify source of interest and struggles	Forever learning how to work with students Step with students in the inquiry process
<b>Intermediate</b>	Continual process of questioning to acquire deeper understanding and make connections Deep engagement with active involvement in learning	Engaging students in learning and inspiring them to think about what they work on Students reflect aloud and think about what they say when they are questioned
<b>Advanced</b>	Repeated immersion in cycle responsible for personal progress in connected learning and building on prior knowledge Reflection of personal learning Personal reflections help reevaluate beliefs and improved ability	Inquiry makes us aware of how students think and see things in their perspective Inquiry cycle creates a web of experiences and understanding Asking questions makes students think and form their own connections

TABLE II: Summary of phrases or actions in personal inquiries and as a mentor

Level of Mentorship	Dialogue with Students
<b>Beginner</b>	Ask questions about what the student worked on. Check technical details and often give direct answers
<b>Intermediate</b>	Asked them where they were struggling, broad purpose of their work and systematic aspects that might not work? Ask about possible approaches to achieve their end-goal Ask students to reflect on their process and provide alternative perspectives
<b>Advanced</b>	Ask the students about what they found interesting and inconsistencies in what they observed Asked them to explain the logic behind their work and the process they went through in figuring out the difficulty? Systematically asked if different segments worked to initiate student's reflective cycle Asked the students what they have tried and were attempting to achieve?

TABLE III: Summary of phrases or actions in student interactions

## VI. CHALLENGES

Over the course of the academic program and from the texture of the reflections we can observe student-mentors' growth and improved verbalization with respect to the cycle of inquiry. As facilitators of the mentor training and instructors of the inquiry-based course there were several identified challenges throughout the years of mentor training. We observed that often there was a disconnect in the communication between the instruction team, the students, and the student-mentors. Some student-mentors could mimic the objectives and verbalize the cycle of inquiry but they were often disconnected from the message of the team. At many points the student-mentors were stuck in the verbalization of a single story, they prioritized self over the students and were not able to engage or inspire students to pursue their creative endeavors. In some cases, the instructors often realized that the student-mentors were

too busy with their academic program and courses to actively engage in the inquiry cycle themselves nor with the students. Additionally, they also found that students with prior knowledge (not necessarily accurate), who were primarily focused on obtaining good grades, were not effective in the cycle or inspiring others. In most of these cases, the facilitators had to wait to see the impact of their mentorship, sometimes for several semesters. Misalignment in learning styles and a lack of a community of learners also impacted the student-mentors growth within the mentorship.

## VII. CONCLUSIONS

The presence of undergraduate student-mentors initiated in the process of inquiry is vital for our freshmen engineering course. The reflections from student-mentors show that with continuous training, reflections and practicing the process of inquiry, student-mentors are able to form deeper connected learning and thinking. In turn, they can facilitate a better learning experience for students. While many students are stuck in the process of obtaining the best grades and getting class work done, student-mentors are encouraging them to step back, think, and reflect on their thoughts and actions. The fact that student-mentors encourage them is meaningful since students feel that they belong to a community of learners and are cared for. The process of mentorship also introduces humility to the student-mentors. They learn that there are different possible views to learn from and not a single path or solution. Thereafter, the student-mentors reach self-actualization. They become engaged in the path of inquiry, seeking to be better with every attempt and modifying their approaches as they learn. Therefore, based on the reflective analysis presented in this work, we believe that inquiry-based learning is a valuable method for students and student-mentors alike.

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