

Exploring Students' Perspectives on the Purpose of Engineering Higher Education in the US

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Abstract— This full paper builds on the work of the first author's PhD dissertation that explores undergraduate Chemical Engineering students' perspectives on why they chose to enroll at a higher education institution in the US. The research brings together capabilities approach and engineering higher education literature in the aim of highlighting students voices. Current literature tends to discuss engineering as a profession, and the history of that profession, and less focused on the purpose of engineering as a degree in itself, which this work aims to change. Capabilities Approach framework, also referred to as the Human Development Approach is concerned with the question of what a person is able to do and be. It also provides a perspective on thinking about purpose of education in terms of instrumental, intrinsic, and social values.

The paper draws on data from a larger project which is focused on the experiences of students studying Chemistry and Chemical Engineering in England, South Africa and the United States of America. We use some of the data from the Chemical Engineering students in the United States in order to explore students' perspectives on the purpose of enrolling in a higher education institution and obtaining an engineering degree. Each case is built around a higher education institution, whereas the embedded units of analysis focus on the students' narratives. The study particularly explores the phenomena from a longitudinal perspective by analyzing data from four different students from the time they enroll in those institutions to the time they graduate, summing up to a total of sixteen interviews. The paper particularly focuses on answering the following research question:

RQ: What are the held perspectives of undergraduate Chemical Engineering students towards the purpose of higher education in the US?

Primary results show a variety of perspectives and reasoning why students pursue an engineering degree. Conforming to societal expectations, securing a job, as well as learning and developing on personal levels all came up and will need to be further investigated. This research is set to address the problem of the neglect of the students' voices in the literature, and to address the lack of research on higher education within the engineering education space.

Keywords—higher education, chemical engineering, capabilities approach, qualitative case study

I. INTRODUCTION

Exploring students' perspective on getting a degree starts with looking more closely at degree options available to them. Currently, an engineering university degree takes on average four years to complete [1], and costs anywhere from thousands to hundreds of thousands of dollars [2]. Another option would be to attend a corporate university with a presumably secured chance of employment waiting on the other side of the process. Alternatives to universities also exist, such as mass open online courses and certificates offered by tech companies [3], [4], which are usually free or cost a couple of hundred dollars, and take anywhere from a few weeks to a few months to complete [5].

These alternative approaches are challenging the established assumption that a university degree is a prerequisite for starting and succeeding at work [6]. Looking at the variables of time and cost, one may argue that those alternative courses are better, or as advertised "better, cheaper, and faster". The logic outlined earlier assumes a correlation between cost, time, and quality, ignores other factors at play, and ultimately boils down the purpose of getting an education to getting a job.

The main motivation behind this research is to understand these factors and the distinctiveness of an engineering higher education degree. Especially from a student perspective where alternatives such as the above mentioned are available to them. An understanding of what makes getting a higher education degree in engineering more valuable to the student may reveal key elements about the purpose of higher education as a whole and contribute to the picture of the future of engineering higher education. The main focus of this paper's argument is that education is more than receiving a degree, especially in technical fields where educating professionals entails developing a sense of social responsibility, functioning in a national and global context, and an understanding consequences of an engineer's work [7].

II. LITERATURE REVIEW

The exploration of prior literature revealed that there are a number of different stakeholders who are concerned with the topic discussed. The perspectives of these stakeholders can be divided into five main sections: 1-economical debates, 2-student perspectives, 3-relation between society and the institution of higher education, 4-external stakeholders (such as industry and policy), and 5-knowledge (creation, legitimation, and transfer).

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Literature looking at higher education as a market is concerned with debates around academic capitalism [8], neoliberalism [9], whether higher education is a public or a private good [10], and the economic and the exchange value of a degree [11]. These studies generally tended to have a warning tone against treating the institution of higher education as a business entity, but yet did not provide a balanced view of what the future of higher education should look like.

To better understand the students' perspective, it is important to explore the different variables that may be influencing that perspective. Things that concern students formation are becoming professionals, or more precisely becoming professional engineers [12], their goals and motivation to pursue engineering [13], their satisfaction with the university as a whole [14], personal growth [15], intellectual growth, and formation of a learner's identity [16].

The third main group of stakeholders is society. Looking at the relationship between society and higher education, social justice and the role of education towards achieving that is a prominent topic [17], as well as the social responsibility that the students who are ultimately members of a given society develop while receiving education [18]. Research on social responsibility tend to be microscopic in nature, and it looks at particular areas where it can be developed through service learning [18], ethics education [19], and more recently through educating for sustainable development as social responsibility [20]. Also, one can think of students being not only members of their society but citizens of the world, and this is what democratic education focuses on or education for citizenship [21].

Another major voice when it comes to literature on higher education is the industry. Literature in the industry space is concerned with the work readiness of graduates [22], the employability of graduates [23], and what career pathways look like for engineers [24]. Part of that perspective as well are standards and codes put by organizations tangential to both industry and higher education. Such organizations in the US, including among many, the National Academy of Engineers (NAE) that dictate the engineering creed, and the Accreditation Board for Engineering and Technology (ABET) that is considered the main regulator of accreditation of engineering degrees.

Lastly, knowledge forms the core of the degree. Legitimation of knowledge, in terms of which bodies of knowledge are deemed worthy of passing on, and its relation to power are all components of studying knowledge in a given field [25]. Two main bodies of literature that are usually discussed tangentially to knowledge are curriculum studies (what goes into the curriculum, concepts and skills, and curriculum development), and accreditation bodies (which can also be grouped with policy stakeholders, or with industry as mentioned earlier) and they can be thought of as almost quality control for knowledge.

After reviewing the summary of the literature above, and taking into consideration possible gaps, the research problem aims at highlighting the students' perspective as the main contributor to what should shape the vision of higher education, and specifically undergraduate engineering students. Also, the

result of this work aims at shifting away from a polar view on higher education, one that contests academic capitalism and social goods, and extending to one that aims to balance social responsibility, learning, and supporting the economy. We argue that higher education systems should achieve instrumental values e.g., jobs, economic development of both the graduate and the society, intrinsic value focusing on knowledge and learning for the sake of learning to advance knowledge, and societal values focusing on social responsibility. This perspective is adopted from the capabilities approach that will be further discussed later [26].

III. THEORITICAL FRAMEWORK

When looking at the literature on the capabilities approach, the two main names that come up are Amartya Sen and Martha Nussbaum. Although their approach to the concepts overlaps and carries similar ideas, one main distinction is Sen's resistance to creating a list of what the capabilities are whereas Nussbaum does provide a list of ten central capabilities as part of the framework. The list includes life, bodily health, bodily integrity, senses, imagination and thought, emotions, practical reason, affiliation, other species, play, and control over one's environment (Nussbaum, 2011). Besides the list directly stated by Nussbaum, and the definitions of capabilities both Sen and Nussbaum provide, they each have goals for human development that help better understand the framework and outline their goals of education (although not particularly higher education). Nussbaum's vision for cultivating humanity has three main capacities (Nussbaum, 1997): 1-critical thinking: the ability to question beliefs and authority for oneself, and accept only those who match one's logical reasoning. 2-world citizenship: a person's ability to think of themselves beyond the locality and hold a sense of responsibility towards the world and humanity as a whole. 3-narrative imagination: the ability to imagine life in someone's else situation, which allows one to understand other's story, emotions, and backgrounds. Sen's goals of education on the other hand are [26]: 1- instrumental: preparation for the economy e.g. getting a job. 2-intrinsic: learning for its own sake, and 3-social: responsibility towards society. By using the capabilities approach as a lens to look at the students experiences, we can evaluate whether or not higher education help to develop the students' capabilities. Applying capabilities approach in higher education enables us to study the purpose of higher education as one that values intrinsic learning, supports economic development, and promotes societal flourishing [29]. The framework proved to be a useful tool in educational settings in previous studies, as it allowed for analysis of how individuals in diverse different contexts convert their resources to functionings [30], and by extension will be applied here to make sense of students experiences during their undergraduate journey.

IV. METHODOLOGY

A. *Methods*

This paper is part of a larger dissertation, which draws on data from an overarching research project on Understanding Knowledge, Curriculum and Student Agency (UKSA). The project is an ongoing collaboration between institutions in the United States (US), England, and South Africa (SA). In each country, two higher education institutions are included with

contrasting features (e.g., city university vs. a town university, residential vs. commuter university). Also, two majors are included in the study, Chemistry, and Chemical Engineering. Those two majors share some basic knowledge in chemistry but provide disciplinary differences between science and engineering for further studies. For scoping purposes, this paper will only focus on Chemical Engineering students in the US.

National context is a key element in this study. Examining the value of higher education in the US will look completely different from examining its value in any other country. For that reason, this research is framed as a qualitative case study. Case studies provide a way to look in-depth at a single phenomenon or a group of people [31], in contemporary times compared to investigating historical events [32] and a preferred research methodology when ‘why’, ‘how’, and exploratory ‘what’ questions are being asked by the research [32]. The nature of the study questions, as stated earlier, is an important clue to ensure case study methodology is an aligned choice for the research design. The questions this paper is aiming to answer is:

RQ: What are the held perspectives of undergraduate Chemical Engineering students towards the purpose of higher education in the US?

The case study in this paper will focus on two institutions, with two embedded units of analysis each, where a unit of analysis focuses on the longitudinal students' narratives from the time they enroll in those institutions to the time they graduate. This led to a total of sixteen interviews being analyzed, the students details are shown below:

TABLE 1: PARTICIPANTS OVERVIEW

| University | Pseudonym | Gender | Nationality |
|------------|-----------|--------|--------------------|
| Argon | Annie | Female | American |
| | Anthony | Male | American |
| Astatine | Jordana | Female | American/Pakistani |
| | Joy | Female | American |

B. Context

The US education system as described by the Department of Education (DOE) is a decentralized one, where there is no national-level control over higher education institutions, also, the titles or degrees granted by universities are not governed by national law [33]. This decentralization and autonomy are unique aspects of the system that the country is trying to protect in order to avoid government control levels seen in many other countries. The US higher education system is partially modeled after the British undergraduate college model and the German research university [34], resulting in a system that has three very different purposes at once: practical training, research, and liberal arts education [35]. To achieve those goals, the US higher education system today has 3652-degree granting institutions with 16.61 million undergraduate students enrolled [36]. Postsecondary education in the US is divided into two branches, the non-degree branch leading to diplomas or certificates, and the other branch, the degree-granting branch e.g. universities, community colleges [37]. The degree-granting institutions can be divided into four main categories: 1- community colleges, 2- public universities, 3-private non-profit universities, and 4-for-

profit institutions. The focus here is on public universities, which overtime registered the highest enrollment number of students under its system [36].

Looking at the case study institutions, Argon is a public land-grant, research-led institution located on the east coast of the US. Being a land-grant institution, the university works to integrate technology into all disciplines to promote positive change around the state and the whole country. As per the most recent enrollment data of Fall of 2020, the university had 30,020 students on campus with 81% being undergraduates and reports a 57% male, 43% female split. As of 2021-2022, the cost of on-campus attendance for one academic year (which includes housing, books, and other personal expenses) is estimated to be \$28,280 for in-state students and \$47,790 for out-of-state students.

Astatine is a public research university established in 1963 that focuses on innovative teaching and learning, research across disciplines, and civic engagement. The university dedicates its mission to cultural and ethnic diversity, social responsibility, and lifelong learning. As per the most recent enrollment data for Fall of 2020, the university has 13,497 students on campus with 81% being undergraduates. The university also reports a 53.6% male, 46.4% female split. As per 2021-2022, the cost of on-campus attendance for one academic year (which includes housing, books, and other personal expenses) is estimated to be \$22,036 for in-state students and \$37,670 for out- of-state students.

C. Data Generation

As mentioned earlier, the data used for this study are part of the UKSA project. The data were generated through conducting semi-structured interviews with the students in the spring semester of each academic year of their degrees. The duration of each interview lasted anywhere between 45 to 60 minutes. The protocol used for the study revolved around nine sections, each targeted at a different aspect of the students’ university experience. Given that the protocol is very detailed and not all of it is relevant to this research. The sections focused on in the analysis corresponded to the participants’ answers to the questions below:

- Have you changed as a person since coming to university? In what ways?
- What do you hope to gain from being here at the university/ Why a university education?
- What is the university responsibility towards you? and vice versa?

D. Data Analysis

Interviews used for this study have already been transcribed by an external professional transcriber and checked for accuracy. The main analysis tools that were used are Word and Excel. Pre-analysis was done to get a sense of what was in the data by reading each student’s transcript for four years as a whole and taking preliminary notes [38]. After that, thematic analysis was followed as a way to capture common patterns of meanings across a dataset to answer the research question [39]. To ensure the thematic analysis is conducted with consistency and reliability, a six-phase process [39] was used as a guide,

while noting that the phases are not necessarily linear, and some of the steps coincide with steps already outlined earlier e.g. familiarizing yourself with the data. Limitations of this analysis include inability to generalize results to a wider population based on the number and context of the participants.

V. RESULTS AND DISCUSSION

This section will discuss preliminary results from four students' interviews, each interviewed for consecutive four years from the time of their admission to graduation. The analysis yield three themes defined as *becoming*- how students view the role of a university degree in what they want to become or do upon graduation, *defining education* – what elements students mentioned and considered part of their education, and *relationship with the university*-where they talk about their particular institution as a representative of the higher education system and how they connect (or not) to that institution. Evidence of these themes were seen across the entire data set with *becoming* being most prominent and *relationship with the university* the least prominent.

A. Becoming

Throughout the interviews, there was a strong sense that the students have towards the degree they are getting and the major they are enrolled at. This is where we see the first theme in terms of how the students eventually viewed themselves, mainly in terms of professional identity. Surprisingly, none of the students saw themselves as becoming Chemical Engineers.

Our first participant, Annie, came into university wanting to do green engineering. She expressed with sadness that green engineering is not offered as a major, so she chose it as a minor. After an internship that Annie completed in her third year, she found a new interest in nuclear engineering and went on to apply to a mechanical engineering degree where she will focus on nuclear engineering in graduate school. Joy also came into university wanting to do environmental work, Chemical Engineering was the department that allowed her to pursue that as a track, and hence she chose the major. The two other participants are becoming doctors. Anthony came into Chemical Engineering on a pre-med track. Following his interviews until his senior year, he did not change his opinion about wanting to become a doctor and successfully applied to medical school and got accepted. Jordana on the other hand, who is on a bio track in her Chemical Engineering department, seemed to pursue medicine mainly out of her family's expectations.

From that perspective, these students did not come to university to specifically become Chemical Engineers, but Chemical Engineering for them was an intermediate step towards something else. That wasn't necessarily portrayed by the students as a negative thing, in many cases they connected the knowledge they gained to what they want to do next, like in the case of Annie, she saw a clear connection between Chemical Engineering and Nuclear Engineering:

"I think that having a chemical engineering degree and going into nuclear engineering will only being an asset even if it's not necessarily seen by everyone who is in the field already as

an asset. It's always given me a different perspective, but as far as I've seen all the research that I've read, all the papers I've read, I think that I'm really well set up to understand all of that. Yeah. So, that's really good. And I do credit all of my chemical engineering knowledge to the university about that." – Annie, year

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B. Defining education

Even though from the previous theme we see how the students at times treated university education as a necessary, or even unavoidable, step to what they want to do later, there were parts of their experience where they focused on learning both academically and learning more about themselves. We see Jordana reflecting on that when asked about her responsibility as a student, and although she starts describing that as a monetary transaction, her reflection expands later in the response:

"I think my responsibility as a student is to get my full tuition's worth of learning out of the school because I'm not just here for the degree. Technically I am but I really think it's important that you're not just paying all this money for a degree, you're also paying for the knowledge that comes with it. And I think as a student, it's important to not only pass and get your degree but do as good of a job you can and try to remember as much as you can." -

Jordana, Year 4

When asked about what he hoped to get out of university, Anthony shared with us what he is learning both inside and outside of class:

"I think the biggest thing that college does is develop students to be on their own, even more so than how much you learn here. I think, it's about learning how to learn, learning how to cook, learning how to take care of yourself, learning how to make friends. I think, it's 10 times more valuable than the actual academic knowledge that you learn. Now, that being said, another thing I was hoping to gain and did gain is just knowledge in the field that I came in knowing nothing about. So, I think academic knowledge, practical knowledge, and then just a degree."-

Anthony, Year 4

It is interesting to see how Anthony mentioned knowledge and the degree separately in those last few lines and how he did not necessarily view the degree as summation of all the other

elements of disciplinary knowledge and personal growth that he mentioned.

Jordana and Joy on the other hand feel that education, and specifically a higher education degree is pushed by society in general and families in particular:

“Why a university degree, because my mom. All right, because in the longterm, if I don't get a degree, then I won't make a lot of money in the longterm. Maybe I will. Chances are, statistics show, if I don't get a degree I probably won't make as much money. I'm not gonna go from janitor to CEO that fast, it doesn't happen. So one, the money, two, my family's super traditional. So if I don't get a good degree, I'm probably not gonna get married well at all, which means I'm probably never gonna live a happy, fruitful life. But really, people who are intelligent want people of their own intelligence. And so if I don't go to university, I'm like, “Oh, screw it. I'm super dumb.”” – Jordana, Year 1

There is a lot to unpack in what Jordana shared, besides her definition of how a university degree is the path to a job, society could judge people's intelligence based on the type of the degree they hold. Engineering carries a lot of social capital and elitism with it.

C. Relationship with the university

There was something special about not just talking about education in general but about being students in those particular universities. Further analysis yet to reveal if this is something specific to these students, to this particular university, or even to the whole educational system. In the case of Annie and Anthony, Annie is a student athlete who represents the university team in competitions and expressed a strong commitment to representing the university as follows:

“Like in athletics, they have a saying that [university name] never comes off. So, wherever you are, you're always representing [the university], so you need to make smart choices about that. You need to be wise in what you're doing and just kind of try to do your best that you can.” – Annie, Year 4

That sense of responsibility towards representing the university in some cases could develop as early as in the first year, like in the case of Anthony:

“[T]he university kind of took a risk in giving you admission to the college, and I think it's our kind of responsibility to respect that and really kind of capitalize on the opportunity we have to study at a

university and do our best, and represent the school well, both now and when we graduate.” – Anthony, Year 1

The relationship with the university may not always be positive, that was mainly expressed through the cost of getting such education. Some students wish they were able to have cheaper education:

“I think it [university]'s out of affordability range for a lot of people who would otherwise be able to benefit greatly from it and would really excel and be beneficial to society. So especially with that education. So I think it's valuable, but I don't think it should be worth 30K a year out of pocket valuable.” – Joy, Year 2

Looking back at the research question and the theoretical framework, the analysis underpinning these three themes provides us with some answers on the different perspectives students hold towards the purpose of getting an engineering higher education degree that could be summarized as follows:

- There is a professional identity developing even if it doesn't perfectly align with the disciplinary knowledge gained, in that sense the student perspective forms around whom they are becoming in terms of their career (mostly instrumental)
- The students have formed a definition for education, but those definitions varied depending on their perspective of what counts as education. Such examples included leaning how to learn, acquiring disciplinary knowledge, and earning a degree (both instrumental and intrinsic)
- Results from the third theme started getting at responsibility, but particularly towards the university and not towards society as a whole

VI. CONCLUSION

The primary results discussed earlier provided some insights into students' perspective of their purpose behind enrolling at an engineering higher education institution in the US. Conforming to societal expectations, securing a job, as well as learning and developing on personal levels all came up and will need to be further investigated. Future stages of this research will expand the data analysis section by looking at more students at other institutions and conducting an international comparative component to enrich the findings of the study.

Potential impact of this work focuses on the students, those who participated in the study, undergraduate students beyond this study, and prospective students of higher education. For the students taking part in the study, the longitudinal aspect provided them with a chance of thinking through and reflecting on their university experience each time they got interviewed. To ensure that goal is achieved, the students had the option to be provided with the transcripts from their previous interviews

upon request. Also, to ensure the students participating feel they are co-constructors of the research, a list of all papers and publications that came out of UKSA will be shared with them after the last round of interviews is completed. Beyond the participants, integrating the students' perspective into the future of higher education is a way to optimize the relevance and value of the education to the students. To get to a different or a better future of higher education, our students' perspective needs to be considered as a factor in that equation. Through that perspective, we will come to better understand the higher education system's underlying value about what it means to be educated, which is arguably not being discussed enough in educational research.

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