# Addressing the Talent Gap in Semiconductors: Motivators and Barriers to Career Choices


Hyo Kang
*Digital Worlds Institute*
*University of Florida*
Gainesville, FL, USA

Serene Cheon
*Digital Worlds Institute*
*University of Florida*
Gainesville, FL, USA

Alice Abia-Okon
*Psychology*
*University of Florida*
Gainesville, FL, USA

Aida Damanpak
*Electrical and Computer Engineering*
*University of Florida*
Gainesville, FL, USA

Wanli Xing
*Educational Technology*
*University of Florida*
Gainesville, FL, USA

Navid Asadizanjani
*Florida Semiconductor Institute*
*University of Florida*
Gainesville, FL, USA



***Abstract*—Background: The United States has made substantial investments to restore the global competitiveness of the semiconductor industry; however, the nation continues to face a shortage of skilled labor in this sector. Despite the importance of this issue, there is limited research examining the barriers in individuals' educational and career choices in the semiconductor industry. To address this gap, our study aims to identify the contextual and psychological factors influencing decisions to pursue academic degrees and careers in semiconductors, using expectancy-value theory as our theoretical framework.**

**Method: We first conducted interviews with engineering students and industry professionals in the semiconductor field to explore potential motivators and barriers. Thematic analysis of the interviews revealed multiple factors related to the utility, cost, and interest value. Based on these findings, we designed a survey and gathered responses from 178 participants, including students, faculty, and industry professionals in the semiconductor field.**

**Findings: The results indicated that utility value (e.g., financial stability) plays a significant role in career aspirations for both industry professionals and students. When making career choices in semiconductors, its relative cost value compared to software engineering (e.g., lower pay, limited remote working) also played an important role. This suggests that semiconductor companies are competing not only with other semiconductor companies but also with other big tech companies, necessitating the provision of a comparable work environment to attract skilled engineers. Furthermore, both students and faculty identified limited lab activities and online resources as major barriers, highlighting the need to enhance accessibility to learning materials.**

**Contribution: This study examines the varied perspectives of students, faculty, and industry professionals concerning the essential factors influencing career aspirations in the semiconductor field. To accomplish this, a survey questionnaire tailored to semiconductor career aspirations was developed, drawing insights from interviews with students and industry experts. The findings provide valuable insights for educational and industry approaches aimed at fostering the future workforce in the semiconductor industry.**



***Index Terms*—STEM career choice; semiconductor industry; barriers and motivators; expectancy-value theory**


## I. Introduction

Semiconductors form the backbone of modern technology, with myriad applications ranging from artificial intelligence to computing devices used in military, telecommunications, and healthcare, thereby playing a crucial role in national security and economic success [1]. Reflecting such a crucial role, the U.S. Congress passed the CHIPS Act in 2022, investing $280 billion to strengthen the domestic semiconductor industry and fortify America's chip supply chains [2]. Despite this historic investment, the country still faces a significant shortage of domestic labor after years of relying on foreign outsourcing. Notably, a recent report from the Semiconductor Industry Association (SIA) projected that the U.S. will require an additional 3.85 million workers by 2032; yet, an estimated 58% of these jobs risk going unfilled without proactive measures [3]. This shortage of labor in the semiconductor field stands in stark contrast to the software engineering industry, indicating systemic factors contributing to barriers among domestic engineering students [4], [5]. To this end, this research aims to address the following questions:

- 1. What are the motivators and barriers to studying semiconductors and pursuing careers in the semiconductor manufacturing industry?
- 2. Are there differences between students, faculty, and industry professionals in terms of the perceived importance of various motivating factors and barriers?

Building upon Expectancy–Value Theory [6], [7], which posits that individuals' motivations are influenced by their beliefs about their own abilities (expectancy) and the perceived worth of the choice (value), we examined the role of multiple factors behind career choices.

This work makes several contributions. Firstly, we employed a mixed-methods approach, starting with interviews to gain a deeper understanding of the perceived barriers in semiconductor education and industry. This allowed us to develop survey questionnaires specifically tailored to the semiconductor field rather than general STEM workforce barriers, providing insights that are directly applicable to the industry. Secondly, we examined differences in perceived barriers among students, faculty, and industry professionals, offering insights into the perspectives of these three distinct groups. For example, our findings suggested that students viewed utility value (e.g., job prospects) as a significant motivator for studying semiconductor, while faculty rated it lower in importance compared to other factors such as a rewarding learning experience. Overall, the findings from our study offer recommendations for future education and policy development aimed at addressing the talent gap in the semiconductor industry, thereby tackling a crucial issue facing the nation.

## II. Literature Background

### A. Characteristics of Semiconductor Workforce

The semiconductor industry presents a unique work environment. First, semiconductor manufacturing is a highly complicated process that involves multiple stages, from fabricating silicon wafers to the intricate assembly, testing, and packaging phases in the back-end pipeline [8], [9]. This process has become increasingly sophisticated and complex over the years; yet, Khan et al.'s 2021 report on the Global Semiconductor Supply Chain suggests that the semiconductor industry still requires labor-intensive processes, posing challenges for workers [10]. Second, the industry also demands a diverse and specialized workforce, ranging from highly skilled engineers responsible for chip design to technicians tasked with operating manufacturing equipment [10], [11]. Each job role within the semiconductor ecosystem requires distinct training and educational pathways [12]. Third, to understand the pipeline of semiconductor manufacturing, individuals should be proficient across various disciplines, including computer engineering, material science, physics, microscopy, and chemical engineering [4], [5]. As such, the complex, multidisciplinary, and labor-intensive nature of the semiconductor industry can pose challenges for engineers.

### B. Factors Influencing Choices: Expectancy–Value Theory

Eccles' expectancy–value theory provides a robust framework for understanding the dynamics of educational and career decision-making [6], [13]. In this theory, "expectation" refers to an individual's belief in their ability to succeed, while "value" pertains to the perceived worth of a specific task [6], [7]. According to expectancy–value theory, career aspirations and decisions are influenced by one's perception of competence and ability (expectation) and the subjective value attributed to the task (value) [7]. Theorists further categorize these subjective task values into interest value (enjoyment), utility value (instrumental value in achieving goals), and cost value (the anticipated psychological and economic implications of choices) [14]–[16]. Using expectancy–value theory as a foundation, Wang and Degol conducted a thorough meta-review to empirically establish connections between various factors and individuals' STEM career aspirations [14]. They suggested that contextual factors, including the school environment and family dynamics, along with sociocultural factors like cultural norms and societal beliefs, collectively shape one's beliefs about their own competency (expectations) and subjective task values (interest, utility, cost), ultimately guiding career decisions. Drawing upon Wang and Degol's framework, we categorized multiple factors into utility, cost, and interest value to explain individuals' career aspirations in semiconductor fields.

TABLE I
INTERVIEW FINDINGS FROM THEMATIC ANALYSIS

| Utility Value |
|---|
| **Motivators: Job prospect**<br>• Diverse job opportunities and growing industry<br>• Financial stability |
| **Barriers: Work environment desirability**<br>• Complex and labor-intensive work environment<br>• Work and life balance<br>• Safety and industry hazard |
| Cost Value |
| **Barriers: Comparison to the software engineering**<br>• Lower pay scale in the hardware area than in the software<br>• Limited remote working options<br>• Less flexible working hours |
| **Barriers: Required advanced knowledge**<br>• Expensive lab equipment and limited accessibility<br>• Require advanced degree (e.g, master, doctoral) for some jobs |
| Interest Value |
| **Motivators: Interest and engagement**<br>• Interest and passion<br>• Rewarding learning experience |
| **Barriers: Less rewarding learning experience**<br>• Difficulty of the subjects<br>• Longer time and patience are required to witness the outcome. |
| Contextual factors |
| **Barriers: Limited educational resources**<br>• Limited course availability until the senior level |
| **Motivators: Support and youth exposure**<br>• Support from family<br>• Early exposure in high school |

## III. Preliminary Study: Interview

### A. Method

Following the guidelines outlined by Rea and Parker [17], we first employed a qualitative research approach and conducted semi-structured interviews to identify potential questionnaire items relevant to the semiconductor industry. The interviews aimed to inquire about the reasons for studying semiconductors in college, motivators for pursuing careers in semiconductor fields, and barriers to entry in the semiconductor field compared to other STEM fields. 13 participants were recruited through convenience sampling. The participants included 6 graduate students, 3 undergraduate students, and 4 industry professionals from Intel, Texas Instruments, Samsung, and TSMC. The participants' majors varied, including electronic engineering, material science, and computer science, with an average age of 27.5. Each interview lasted approximately 30 minutes.

### B. Results and Discussion

The thematic analysis was conducted using MAXQDA [18]. Following the guidelines outlined by Braun [19], two independent researchers reviewed the interview transcripts and created the initial open codes, resulting in over 30 codes. The researchers engaged in a series of discussions to develop axial coding by reviewing the frequency of each theme in the data. Based on Wang and Degol's career choice framework, sub-themes were categorized into utility value, cost value, interest value, and contextual factors [14]. The findings of the thematic analysis are summarized in Table 1.

Regarding motivators for pursuing semiconductor careers, eight respondents cited job prospects, emphasizing financial stability and industry growth. In discussing job prospects and work environment of the semiconductor fields, participants frequently made comparisons with software engineering. Two hardware engineer participant highlighted the disparity in pay between software and hardware roles, emphasizing the challenges faced by hardware engineers, such as frequent exposure to noise and chemicals in the fab.

> "Based on some of the engineer friends that I've talked to, people in semicon prefer the software side over the hardware side of the chip...The pay they give for the software side of the chip is much, much higher."

In discussing barriers to studying and entering the semiconductor field, participants noted the extensive knowledge and experience required for circuit design and the time-consuming nature of hardware development.

> "It's very difficult to become a circuit designer unless you have years of experience or an advanced degree. You need a whole different knowledge base because you need to consider temperature, cost, material, as chips are getting smaller every year and it's changing fast."

## IV. Survey: Motivators and Barriers

### A. Methods

Drawing upon interview findings and thematic analysis, we identified 5-6 commonly cited factors that serve as motivators and barriers for educational and career aspirations. These insights were instrumental in formulating a survey questionnaire. The survey comprised three sections: The first section asked respondents about their perceptions of motivating factors and barriers for engineering students in college (*"For engineering students in college, what do you consider to be important motivating factors to study semiconductors?"*). This section included 5 items for motivating factors, such as good job prospects, interest and passion, a rewarding learning experience, ease of understanding the subject matter, and support from family. Additionally, 6 items were included as barriers, as illustrated in Table 2. The second section addressed the perceptions of motivating factors and barriers for engineers in the workplace (*"For engineers in the workforce, what do you believe are crucial motivating factors to pursue careers in the semiconductor industry?"*). This section included 6 items for motivating factors and 6 items for barriers. Each questionnaire item was answered on a 7-point Likert scale (1: not important at all, 7: very important). The third section inquired about individuals' intrinsic and extrinsic motivations, cultural differences, and demographic factors.

### B. Participants

The survey was specifically targeted at three groups residing in the United States: 1) students studying semiconductors, 2) faculty teaching semiconductors, and 3) industry professionals in the semiconductor field. Student participants were primarily recruited through an email list of the Semiconductor Career Readiness Student Organization (SCRO). Faculty were recruited through convenience sampling via the university's email lists. Industry professionals were mainly recruited through social media postings targeting semiconductor professional groups on LinkedIn, Reddit, and Facebook.

A total of 254 responses were received. We excluded responses from outside the United States and incomplete responses, resulting 178 valid responses. Among the 178 respondents, 45 were students, 23 were faculty members, and 110 were employees in the semiconductor industry. The majority of the participants (44%) were aged 35-39 years, followed by 21% aged 30-34 years, 13% aged 24-29 years, 14% aged 18-24 years, and 10% aged 40 years or older. In terms of race and ethnicity, 72% of respondents identified as white, 21% as Asian, 3% as Black or African American, and 3% as Hispanic or Latino. Among the industry employees, 33% worked in IC design and development, 25% in manufacturing (e.g., operations and production), 11% in packaging, 4% in IT and software, and 7% in other areas (e.g., R&D, supply chain, logistics). Eighty-two respondents provided information about their current employers. These companies varied, including Intel, TSMC, AMD, Texas Instruments, Apple, Accenture, Aixtron, KLA, Onsemi, Omnivision, Qualcomm, and more. Regarding majors, 26% studied electronic engineering, 24% computer science, 13% industrial engineering, 11% materials science, and 11% chemical engineering. The average annual income of industry professionals was $105,000.

### C. Results

***Motivators and Barriers:*** Table 1 includes the findings on the motivating factors and barriers. Regarding the motivators for studying semiconductors in college, participants (combined $n$ = 178) rated good job prospects highest, followed by interest and passion, a rewarding learning experience, ease of understanding subject matters, and support from family. When it comes to motivators for career choices, financial stability and good job prospects were considered the most important by participants. While interest and passion were ranked as the second most important motivating factors for seeking an education in semiconductors, the same factor was rated as the least important factors in pursuing careers in semiconductor fields. Regarding barriers, respondents indicated that limited lab activities and expensive equipment are significant

TABLE II
MOTIVATORS AND BARRIERS IN STUDYING SEMICONDUCTORS IN COLLEGE AND PURSUING CAREERS IN THE SEMICONDUCTOR INDUSTRY: COMPARISON BETWEEN STUDENTS, FACULTY, AND INDUSTRY EMPLOYEES

| | Combined (n=178) | Students (n= 45) | Faculty (n=23) | Industry (n =110) | *F*-value | *p*-value |
|---|---|---|---|---|---|---|
| ***Motivators for studying semiconductor in college*** | | | | | | |
| Good job prospect | 5.13 (1.66) | 5.81 (0.98) | 4.46 (1.80) | 5.01 (1.69) | 2.890 | 0.05* |
| Interest and passion | 5.01 (1.74) | 5.87 (1.14) | 4.33 (1.91) | 4.81 (1.74) | 3.574 | 0.03* |
| Rewarding learning experience | 4.82 (1.64) | 5.10 (1.59) | 4.96 (1.65) | 4.68 (1.58) | 1.785 | 0.17 |
| Ease of understanding the subject matter | 4.64 (1.74) | 5.12 (1.54) | 5.06 (1.57) | 4.37 (1.77) | 2.184 | 0.11 |
| Support from family | 4.32 (1.74) | 5.25 (1.48) | 4.26 (2.08) | 4.10 (1.71) | 3.097 | 0.04* |
| ***Motivators for pursuing a career in semiconductor industry*** | | | | | | |
| Financial stability and good job prospect | 4.97 (1.84) | 5.42 (1.17) | 4.93 (2.01) | 4.95 (1.90) | 0.986 | 0.37 |
| Supporting work environment | 4.84 (1.74) | 4.89 (1.31) | 4.68 (2.15) | 4.74 (1.67) | 0.771 | 0.46 |
| Work-Life balance | 4.77 (1.76) | 5.05 (1.67) | 5.00 (1.63) | 4.65 (1.74) | 0.585 | 0.55 |
| Diverse career options | 4.56 (1.67) | 4.83 (1.25) | 4.50 (1.75) | 4.46 (1.72) | 1.571 | 0.21 |
| Passion and interest | 4.44 (1.80) | 4.79 (1.54) | 4.63 (2.12) | 4.27 (1.77) | 2.184 | 0.11 |
| ***Barriers for studying semiconductor in college*** | | | | | | |
| Limited lab activity and expensive equipment | 4.81 (1.71) | 5.00 (1.06) | 5.25 (1.64) | 4.65 (1.79) | 0.585 | 0.55 |
| Limited course offering and resources (e.g., online lecture) | 4.79 (1.76) | 5.33 (1.69) | 4.78 (1.62) | 4.58 (1.62) | 2.697 | 0.70 |
| Limited job opportunities than other fields (e.g., software engineering) | 4.79 (1.80) | 4.88 (1.99) | 5.21 (1.74) | 4.67 (1.78) | 1.366 | 0.70 |
| Difficulty of the subject | 4.55 (1.78) | 5.06 (1.69) | 4.73 (1.53) | 4.31 (1.82) | 0.986 | 0.37 |
| Lack of support from family | 3.78 (1.71) | 4.21 (1.69) | 4.12 (1.96) | 3.54 (1.78) | 1.358 | 0.26 |
| ***Barriers for pursuing careers in semiconductor industry*** | | | | | | |
| Lower pay than other fields (e.g.,software engineering) | 5.05 (1.25) | 5.41 (0.79) | 5.50 (1.46) | 4.81 (1.69) | 2.112 | 0.12 |
| Require advanced degrees | 4.63 (1.66) | 5.31 (1.26) | 4.56 (1.82) | 4.38 (1.69) | 2.834 | 0.05* |
| Less flexibility and remote working options | 4.50 (1.78) | 4.96 (1.41) | 3.81 (1.97) | 4.46 (1.75) | 1.865 | 0.15 |
| Complexity of the work | 4.47 (1.69) | 4.87 (1.28) | 5.00 (1.59) | 4.21 (1.75) | 2.512 | 0.08 |
| Lack of supporting environment | 3.94 (1.66) | 3.91 (1.58) | 3.87 (1.92) | 3.97 (1.61) | 0.311 | 0.96 |

Note: *significance at 0.05 ; Mean (Standard Deviation).

obstacles to studying semiconductors in college, followed by limited course offerings and resources, as well as limited job opportunities. As for the barriers to pursuing careers in the semiconductor industry, the lower pay compared to other fields was rated the highest among other factors.

***Comparison between Students, Faculty, Industry Professionals:*** To examine the differences in the perceived importance of each factor among three groups, a series of ANOVAs were conducted. Notably, good job prospects were considered a critical motivator for studying semiconductors in college among students ($M$ = 5.81, $SD$ = 0.98) and industry professionals ($M$ = 5.01, $SD$ = 1.69), while faculty rated it relatively lower (M = 4.46, SD = 1.80; $F(2,178)$ = 2.890, $p$ = 0.05). Interest and passion were also rated relatively high among students ($M$ = 5.87, $SD$ = 1.14) than faculty ($M$ = 4.33, $SD$ = 1.91). The subsequent post-hoc analysis with Tukey's test showed significant differences between students' and faculty's perceived importance of interest and passion ($p$ = 0.03). Among faculty, ease of understanding the subject matter was rated highest among the five motivating factors ($M$ = 5.06, $SD$ = 1.57). Regarding the barriers to pursuing careers in the semiconductor industry, the requirement for an advanced degree showed a statistical difference between the three groups($F(2,176)$ = 2.834, $p$ = 0.05). Specifically, the requirement for an advanced degree was rated as the second most critical barrier among students ($M$ = 5.31, $SD$ = 1.26), while faculty and industry professionals considered it lower than other factors.

## V. DISCUSSION

Overall, the findings highlight that utility value, such as job prospects and financial stability, are critical factors in pursuing an academic degree and making career decisions. It is also noteworthy that engineering students and industry professionals evaluate such utility values compared to other tech industries, citing the higher payscale and more flexible work environment in software engineering as major cost concerns in choosing careers in the semiconductor field. This suggests that semiconductor companies should develop strategies to provide comparable work environments for engineering students to attract and retain talent. These findings align with previous reports, emphasizing the importance of automation to enable flexible and remote working arrangements, thereby reducing the labor-intensive nature of semiconductor assembly, packaging, and testing [4], [11].

For student respondents, intrinsic interest value was an important motivator to study semiconductors; however, the limited course offerings and lab activities were perceived as critical barriers to seeking academic study in the field. Additionally, it is noteworthy that students considered the requirement of an advanced degree as a critical barrier for entry into the semiconductor industry, while industry professionals rated it relatively lower. This indicates a possible disparity between students' perceptions regarding the necessity of a graduate degree for their employability and the expectations of industry professionals. It is possible that students might not feel sufficiently prepared for their careers without an advanced degree, due to the difficulty of the subject. Combined, these findings highlight the need for future educational programs that could bridge the gap between students' perceptions and industry expectations through lab-based hands-on activities to help students feel better equipped with the industry-required skillsets. The limited accessibility of online resources is another important factor that could be addressed in future educational programs.

## VI. Limitation and Future Study

This work-in-progress study has multiple limitations that need to be addressed in the future study. One major limitation in our preliminary survey is the unequal sample sizes among the student($n = 45$), faculty ($n = 23$), and industry professionals ($n = 110$), which makes direct comparisons between the three groups less robust with ANOVA [20]. Additionally, different recruitment methods were employed: students and faculty were recruited through traditional university mailing lists, while industry professionals were recruited via social media channels, which could introduce potential biases [21], [22]. Building on these preliminary findings, the subsequent future study will aim to recruit more participants from the student and faculty groups to enable a more robust analysis and comparison. It will also employ various data analysis methods, including the Simple Relative Index [23] and Spearman Rank Correlation Coefficient techniques [24] to identify the level of importance and degree of agreement between the responses of the three groups.


## Acknowledgement

This study was funded funded by the U.S. National Science Foundation (Award Number: 2346819).


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