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Left on their Own: Confronting Absences of AI Ethics Training among Engineering Master's Students

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Abstract

Although development of Artificial Intelligence (AI) technologies has been underway for decades, the acceleration of AI capabilities and rapid expansion of user access in the past few years has elicited public excitement as well as alarm. Leaders in government and academia, as well as members of the public, are recognizing the critical need for the ethical production and management of AI. As a result, society is placing immense trust in engineering undergraduate and graduate programs to train future developers of AI in their ethical and public welfare responsibilities.

In this paper, we investigate whether engineering master's students believe they receive the training they need from their educational curricula to negotiate this complex ethical landscape. The goal of the broader project is to understand how engineering students become public welfare "watchdogs"; i.e., how they learn to recognize and respond to their public welfare responsibilities. As part of this project, we conducted in-depth interviews with 62 electrical and computer engineering master's students at a large public university about their educational experiences and understanding of engineers' professional responsibilities, including those related specifically to AI technologies. This paper asks, (1) do engineering master's students see potential dangers of AI related to how the technologies are developed, used, or possibly misused? (2) Do they feel equipped to handle the challenges of these technologies and respond ethically when faced with difficult situations? (3) Do they hold their engineering educators accountable for training them in ethical concerns around AI?

We find that although some engineering master's students see exciting possibilities of AI, most are deeply concerned about the ethical and public welfare issues that accompany its advancement and deployment. While some students feel equipped to handle these challenges, the majority feel unprepared to manage these complex situations in their professional work. Additionally, students reported that the ethical concerns involved in the development and application of technologies like AI is often not included in curricula or is viewed as "soft skills" that are not as important as "technical" knowledge. Although some students we interviewed shared the sense of apathy toward these topics that they see from their engineering program, most were eager to receive more training in AI ethics. These results underscore the pressing need for engineering education programs, including graduate programs, to integrate comprehensive ethics, public responsibility, and whistleblower training into their curricula to ensure that the engineers of tomorrow are well-equipped to address the novel ethical dilemmas of AI.

Introduction

The prevalence of ethical challenges in engineering, particularly in the field of artificial intelligence (AI), is a growing concern to both experts and the lay public. Research indicates that a significant majority of engineers face ethical dilemmas during their careers; over 70% of professional engineers have encountered ethical issues in the workplace and approximately a quarter find it challenging to align their professional ethics with their employer's demands [1]. This ethical complexity is especially pronounced in AI development, where engineers often lack adequate guidance in ethical complexities of designing technologies that augment or replace human cognition [2].

While many employed engineers receive cursory public welfare training on the job, workplace training is typically insufficient and ineffective. Findings from a nationally representative survey of engineers revealed that despite nearly half (46%) of engineers receiving ethics training in their workplaces, it does not significantly enhance their awareness of professional responsibilities towards public welfare [3]. Furthermore, workplaces often prioritize corporate and organizational goals over public concerns, potentially limiting engineers' capacity to voice ethical considerations [3], [4], [5], [6].

Given the shortfall of effective ethics and public responsibility training in other institutional contexts [3], engineering education programs have tremendous responsibility to train engineers to navigate potential ethical and public welfare concerns of AI [7], [8], [9], [10]. Public welfare responsibility training in engineering education may take several forms from formal curricular and pedagogical approaches in required engineering courses to co-curricular activities [11], [12], [13]. Although some research has raised questions about the efficacy of this training long-term, there is growing consensus that ethics training in engineering education can have an enduring impact on how employed engineers understand and respond to their public welfare responsibilities and how they might approach ethical concerns in the future [3], [14], [15].

It is thus critical to understand the extent to which engineering students feel prepared by their engineering education to handle ethical issues related to AI. In this project, we focus on the perspectives of engineering master's students in ECE. Traditionally, most research on ethical training in engineering education has focused on undergraduates. That perspective is important, as undergraduate education is the gateway for most engineering practitioners, but engineers with graduate-level education are more likely to go directly into organizational leadership positions and be engaged in high-level technical decision-making. As such, understanding their exposure to the ethical concerns of AI in their master's programs is vital for grasping how the next generations of engineers are grappling with the challenges that current and emerging AI technologies will create.

Research Questions

Drawing on interviews with 62 electrical and computer engineering (ECE) master's students (described in more detail below), we explore three broad questions related to their perspectives on AI.

(1) What opportunities and dangers do ECE masters students see in artificial intelligence broadly? Do they exhibit unbridled enthusiasm for AI's potential? Are they apprehensive or fearful of AI developments and what an AI-saturated future will hold? As the future leaders of these technologies, ECE masters students are bellwethers for the views of the engineering profession more broadly.

(2) Do these ECE masters students feel equipped to handle the ethical challenges and dilemmas of AI technologies? As they reflect on their past and current training in engineering across institutional contexts (including but not limited to their formal engineering education and work experiences), do these students feel as though they are receiving the training and guidance that they need to navigate the complex landscape of AI development and management? Or do they feel ill-equipped to face these ethical and professional challenges, even if they have the technical capabilities to engage in this work?

(3) *To what extent do they hold their engineering education programs accountable for (in)adequate training?* If ECE masters students express concern about the ethical dilemmas accompanying AI development and feel ill-equipped to face these dilemmas in their engineering work, do they hold their engineering education responsible for this training? Although engineering education programs may seem like obvious sources for this training, that does not necessarily mean that engineering master's students would ask for or even want such training. Indeed, engineering education in general is beset with curricular, pedagogical, and cultural challenges to the incorporation of ethics training. The crowding out of professional responsibility considerations by technical content, the (perceived) lack of expertise among engineering educators to teach about ethical issues in the workforce, and cultural ideologies that cast ethical considerations as tangential or even politicizing to "pure" technical design work means that ethics training is neither a regular nor broadly valued element of engineering education [7], [16], [17], [18], [19]. We are interested in the extent to which ECE masters students believe that such training is missing from their engineering programs in ways that may lead them to pressure their graduate instructors and advisors to provide this training.

Methodology

We conducted in-depth interviews with 62 students in the second year of their master's program in an electrical and computer engineering department at a large public university in the Midwest. The name of the university is redacted to protect the confidentiality of respondents.

Using the entire list of students in the master's cohort, we created a stratified random sample that over-sampled women, domestic students, and non-Asian students of color. This over-sampling was intended to ensure sufficient representation from historically minoritized groups in the final interview sample. Among our interviewed cohort, 38.7% identified as women and 61.3% as men, 74.1% were primarily raised in countries outside of the United States, and the average age of interviewees was 25 years (range 22-42 years). Based on students' self-identified race/ethnicity, the cohort was 48.3% Asian, 29% South Asian/Indian, 14.5% White, and 8.1% Black, Hispanic, or Middle Eastern. We do not further disaggregate the latter category to protect confidentiality. Nearly all interviewees had a variety of internship experiences and a little less than half held full time jobs between their undergraduate training and their returning to graduate school.

We invited students in this sample to participate in a 60–90-minute one-on-one interview over zoom. The interview was advertised as a research study investigating ECE students' experiences in engineering education and students' viewpoints of the engineering profession. To ensure sufficient interview sample size, we interviewed members of two successive cohorts in Spring 2022 (37 interviewees) and Spring 2023 (25 interviewees). This meant that our interview sample encompassed a cohort of students who had the first year of their master's program primarily through remote education (due to the COVID-19 pandemic) as well as a cohort of students who took all their classes under standard post-pandemic in-person instructional protocols. The second interview period also coincided with launch and subsequent public debates around ChatGPT (OpenAI, San Francisco, USA) and other similar generative AI models.

All interviews were conducted by the first author virtually using video conferencing. They were offered a $50 gift card as a token of gratitude for their time and participation. The interviews began by gathering information about respondents' educational and employment history and their prior training in ethics and public welfare responsibilities. After asking about their experiences in their current master's program, we asked them about their views on engineers' professional responsibilities broadly and their thoughts about ethical engineering issues specifically. Because of the unique timeframe in which we conducted the second round of interviews (Spring 2023), we also asked those students about their experience with and opinions of ChatGPT and other emerging generative AI technologies explicitly.

The coding scheme was developed iteratively by the first and second author. Interviews were first coded thematically for central concepts from the interview guide, and then were coded again inductively with specific attention to the three questions outlined above using Atlas.ti Mac (Version 9.1.3). In our analysis for this paper, we paid particular attention to respondents' perspectives on AI and their thoughts about training they had received in engineers' ethics and public welfare responsibilities. We looked for systematic differences in response patterns by gender, race/ethnicity, and whether they were a domestic or international student and include demographic information for quoted respondents. Except where we note below, these patterns were quite consistent across these axes.

Results

What opportunities and dangers do engineering master's students see in AI?

Many students we interviewed frequently used or had experimented with AI models themselves. Most were impressed with the capabilities of the algorithms from a technical perspective, and some were eager for their potential to help with communication in their field of work. One student stated that, "using ChatGPT to smooth over your writing is definitely a positive" especially for students for whom "English is not their first language" (P57 White man domestic student). Similarly, another student used AI to translate "niche technical terms" from lectures into more easily understood descriptions (P55 Black woman domestic student). There was general appreciation for AI technologies and a sense that "AI is not going to replace humans. AI is just going to become a tool that humans are gonna coexist with" (P42 Asian man domestic student). This student described unique opportunities for "collaboration" between humans and AI. When sharing about a situation in which a professional board game player watched AlphaGo, a computer programmed to play the board game, he was immensely impressed at how humans can gain new knowledge and skills from interacting with AI models:

> "The AI was able to show [the player] dimensions of the game that he had previously not been able to see before. That to me was like amazing because the AI was able to show something that a human may have taken years to have developed on their own. That ability for the human to learn from the AlphaGo AI was very, very, very beautiful" (P42 Asian man domestic student).

This sentiment was shared by other students who noted the ability for AI technology to save time and effort: AIs can "advance things a lot faster [so] you eventually would not need to spend that much time on problems that we spend time on right now" (P58 Indian woman international student).

Despite students' interest in AI technical abilities and hope that it will be used for good, most students we asked directly about generative AI were wary about how the rapid influx of these tools over the past few years will impact society in the long run. "I feel like that's something that was released without fully knowing what the societal consequences are. Certainly, there's gonna be a lot of benefits to that tool, in my opinion, but there's also gonna be certain drawbacks. A lot of times, those drawbacks aren't apparent until after the tool is released to the public" (P57 White man domestic student).

Specifically, students expressed concerns about the development process and varied applications of AI technologies. Interviewees frequently shared their worries about the training methods and the sourcing of training data. This included issues of fairness (e.g., compensation for artists and authors whose work is used to train AIs) and the potential for designers to unintentionally incorporate social biases in AI algorithms. As one student explained, "there is a huge possibility

of biases. For example, if we're training these models with White men, and those biases then go in and it's not able to generalize well towards the entire population, that can bring out problems" (P59 Indian woman international student). Importantly, students recognized the tangible impact that these encoded biases can have on end users. One student provided an example of how "big data" and algorithms determine credit scores:

> "The algorithm that's used to determine that is so mysterious. No one really knows what's going into it and how different companies aggregate that data and make a determination on someone['s score]. A lot of people say the algorithm isn't going to discriminate, but [it can]" (P02 White man domestic student).

The concern regarding the inner workings of AI models and smart devices was intensified among ECE students who, reflecting on their own lengthy training, realize that most users lack this expertise and might unknowingly expose themselves to risks. "All of us are using small AI tools at home with Siri and Alexa, and I feel all these tools are constantly listening and capturing data because that's how these things work and that's how [future] data sets get trained. I'm not sure if all the customers are aware of it" (P56 Indian woman international student). Another student clarified that, "AIs can simply learn your preferences by your daily habits, and they can come to know who you are. It's a really big concern about privacy" (P37 Asian man international student).

Similarly, because of their master's level training in the subject, students were highly aware of how much power these models required for adequate training and computation phases and lamented how much energy was needed for merely slightly improved performance. "AI companies … are investing a lot in their computation ability and it's really energy-consuming … AIs are consuming more and more energy, more and more greenhouse power, [for] minimal benefits" (P37 Asian man international student).

However, students' biggest worries about AI were about the inappropriate, unethical, and dangerous applications of AI technologies by end users. This included concerns such as the incorporation of "artificial intelligence into the military" and using AI to "kill people more efficiently" (P37 Asian man international student), "scamming people" (P55 Black woman domestic student), and the fact that "students are already getting caught…using ChatGPT" to plagiarize and cheat in school (P39 White man domestic student).

Many students also noted the harm that could be done by generative AI spreading misinformation and creating deceptively fake images. For example, "if you use ChatGPT … some of the conclusions it makes, or the way it portrays information is obviously wrong" (P54 Indian woman international student). Likewise, one student explained that if "you ask the model to generate an image containing a human's face, it could be risky. You don't know whose face will be generated. It could be some people's face in the dataset they used to train the model" (P44 Asian woman international student).

Overall, these ECE master's students generally appreciate the technical capabilities of generative AI and see its potential for learning, collaboration, and efficiency in their fields. However, they express concerns about the long-term societal impact, the potential biases inherent in AI technologies, and harmful environmental effects. The biggest ethical concerns voiced by students related to the misuse of AI for spreading misinformation and creating deceptive content, and the potential for harm that these technologies pose. The prevalence of these concerns was similar across students' gender identity, race/ethnicity, and whether they were domestic or international students.

Do they feel equipped to handle the challenges of these technologies?

When students were asked if they felt equipped to handle the ethical challenges and dilemmas of AI technologies, they offered mixed and nuanced responses. Some agreed at the outset that they had sufficient knowledge and training. Many students described having general knowledge of who to go to or how to report ethical concerns within their company or school. For example, one student explained, "Here within the scope of my university, I know that, if I see any such violation of human boundaries, or honor code of ethics, I know that it's my responsibility to speak up" (P12 Indian man international student). Similarly, some students with experience in the workforce expressed confidence that their employers would do the right thing and felt sufficiently familiar with their workplace protocol for drawing attention to any concerns. As one student explained, "speaking to my current organization that I work for, I know my first step would probably be speaking to my managers about it, [whom] I have a lot of trust and faith in, and I think they're good people" (P57 White man domestic student). However, when pressed to consider a circumstance in which their concerns were brushed aside, most students were unsure of next steps to take. That same student continued by saying, "to be honest, if [my managers] weren't receptive to that for some reason, past that, I'm not sure if I'm equipped to know what to do in that situation; probably not." (P57 White man domestic student).

More than half of students stated that not only did they feel ill-equipped to handle these situations, often they had never even considered them as a possibility. After giving the question some thought, one student responded that their reaction "depends on the scale of it or how much it personally impacts me or the people around me. I actually don't know how I would actually respond now that I'm thinking about it. Never really had to think about that kind of stuff before" (P04 White man domestic student). Likewise, another student appeared concerned and was hesitant about their potential reactions: "If I'm experiencing something [unethical], I probably won't respond the correct way 'cause … I [would be] dealing with that with no experience … who knows how I'll react" (P10 Indian man international student).

A handful admitted that they would not know what to do if an ethical issue arises, but also believed that such knowledge is unimportant or unnecessary for their work. For example, a student brushed off the idea of speaking up outside their company if they were aware of something unethical: "Who in the world do you send this information to? I gotta google search some department? I don't know how that department works. Some federal department? No. I don't know who I need to contact and nor do I really care about contacting anyone" (P03 Asian man domestic student).

Much more commonly however, students were eager for additional information on how to approach ethical issues related to AI. One student appeared to realize during the interview they had a large knowledge gap in this area, and she expressed a desire to learn more:

> "Ethics is something I've always heard about, but I'm not really trained to know how to respond or how to make it better. And also whistle blowing … I think those skills are something I'm lacking … I don't know a lot about how to navigate difficult situations when I'm faced with these ethical dilemmas, so that's something I'm definitely gonna look into" (P53 Indian woman international student).

In general, interviewees showed mixed feelings about their preparedness to handle ethical challenges relating to AI technologies. We did not find broad differences in these patterns across students' gender, race/ethnicity, or domestic/international status. While some felt confident in their knowledge of reporting mechanisms within their companies or schools, others had only a vague understanding. The majority, however, felt unprepared and inexperienced in dealing with such issues, expressing a need for further education and guidance on navigating ethical dilemmas and whistleblowing processes.

Do they expect and rely on engineering educators to train them in ethics and responsible conduct?

There was general consensus among interviewees that neither their undergraduate training nor graduate engineering training adequately prepared them for handling their public welfare responsibilities as engineers or navigating difficult or unethical situations in the workplace. One student illustrated this point by commenting, "I don't think any courses or lectures or any kinds of education, or all the experience I have mentioned have actually prepared any engineer for [something unethical]" (P23 Asian man international student). Another student explained they were not prepared to consider the societal effects of AI because, "to be quite frank, in a standard engineering education, you don't really discuss or develop any education for the philosophical and moral implications of the work" (P57 White man domestic student).

Many students commented that there was little time in the curriculum granted to discuss ethics and professionalism because there was so much other technical content to cover. "A lot of the graduate classes that I took were very much focused on very specific technical things, like how to actually design a microwave server [or a] certain antennae. We didn't really have any real experiences or any real talks about ethics" (P04 White man domestic student). This viewpoint that technically specific content was valued the most within engineering education was shared among many students. Another stated that their takeaway from the university was that an engineer's job was solely technical; other people were responsible for ethical considerations:

> "In my undergrad, the focus was a lot more on developing your technical skills. They don't really have any professional development or communication skills improvement, things like that… It focused a lot on just being a very good technical engineer. If you had the technical knowledge, you were a good engineer. If you didn't have the technical knowledge, you were a bad engineer, whether you were ethical or not, that didn't concern you because there was another team, the legal team that looked after it" (P40 Indian woman international student).

Furthermore, students appeared frustrated by the lack of training and this dismissive attitude in their training toward professional welfare within their schooling. One student explained that the culture of their engineering department minimizes the importance of lessons on how to be an engineer in the workplace: "There seems to be, actually, a large disconnect in that [educators are] like, 'we live in academia, so here we're talking about optics on driving these equations and things like that. The actual practice of engineering, you'll figure out when you get into the real world'" (P07 White woman domestic student).

However, it was not uncommon for students to share this apathy towards ethical considerations of their engineering education programs. One student expressed frustration at the idea of needing to learn about ethics at all and complained, "if I'm paying money to attend ethics class as an engineer, I'm gonna be furious. I pay for technical classes. Not for ethics classes" (P03 Asian man domestic student).

Oftentimes students viewed ethics classes as "just a box to check off and … an annoyance" (P41 White man domestic student). This perspective was shared by students who saw these trainings as a blow-off class; "most of the people who go to ethics classes, they're not completely interested in actually learning work ethics at all. They just want an easy course" (P18 Indian man international student).

Alternatively, some students explained that ethics and professional responsibilities would be better learned on the job or through experience than in the classroom. As one student explained,

"as bad as it seems, I don't really pay that much attention to ethics and AI [in class]. I was like: 'I can learn that through my research, right?'" (P16 Indian man international student).

Students justified these views by saying ethical concerns were not within the scope of their responsibilities; they believed that other individuals (e.g., human resources, corporate legal departments, or governmental regulators) would be better equipped to handle those issues. Some students frequently minimized their public welfare responsibilities by claiming they were merely a cog in the corporate wheel or too low down in the chain of command to have significant influence on project decisions. Other students rationalized this attitude by stating that their engineering specialization had nothing to do with ethics and their projects were too abstract and therefore had no implications for broader society and could not negatively affect users.

However, in contrast to these views, two thirds of students we interviewed were eager for more training in AI ethics and wanted additional professional skill development and instruction on how to handle ethically challenging situations. One student shared that "the engineering curriculum probably would benefit more from more of an emphasis on soft skills and things like ethics. Although that's difficult to teach, it definitely could be, and probably should be, a larger part of the curriculum" (P41 White man domestic student). Similarly, another student lamented that there should be "a course in undergraduate school [about how] to do the right things because … many people don't know what the right thing" to do really is (P60 Asian woman international student).

Additionally, some students expressed a desire for change in the culture of engineering more broadly; students want their mentors, faculty, and administrators to take ethics more seriously and place more value on public welfare considerations. One student summarized this aspiration by saying,

> "I've definitely noticed a little bit of a culture of, 'who cares?,' and… blowing [ethics training] off. … It's like one day out of a full semester course where we talk about these issues. I think certainly there's a happy medium. You can't just talk about ethics the whole time. You have to learn about your actual technical content, but I do wish—and I hope in the future—this culture of 'oh, I'm just in engineering for the money,' or 'I'm good at math, so I'm gonna go work on stuff. I don't care if I'm making drones,' I hope that that goes away. … Even then, there's only so much [school] courses can do to change culture. I hope there's a ground up change in culture" (P57 White man domestic student).

Broadly, students widely agreed that their undergraduate and graduate engineering training did not adequately prepare them for handling ethical issues and professional responsibilities in their careers generally and around AI issues specifically. They felt that their engineering departments' curricula heavily focused on technical skills at the expense of ethics and professional

development, leading to a perception that ethical considerations were secondary or irrelevant to their role as engineers. Women expressed this sentiment more frequently than men, but there were no other notable demographic differences in these results patterns. Despite some apathy towards ethics education among students, the majority of students expressed a desire for more emphasis on professional development and ethics training in their graduate engineering programs and for both schools and workplaces to take public responsibility considerations more seriously.

Discussion

In this interview-based study, we explored how electrical and computer engineering master's students consider the potential ethical concerns associated with AI technologies, their perception of their preparedness to handle ethical challenges in the workplace, and the adequacy of their educational training in readying students for their ethical and public welfare responsibilities.

Our research reveals that students were quite cognizant of ethical concerns surrounding AI development and deployment. While students acknowledged the technical power and potential benefits of AI, nearly all expressed concerns about long-term societal impact, equity of algorithm training methods and sources of embedded bias, and the contribution of AI to loss of privacy and spread of misinformation. These concerns were heightened by the recognition that most lay users may be unaware of the risks associated with using AI and smart devices.

The findings also indicate there is a notable lack of preparedness of these master's students to deal with ethical dilemmas in their workplaces. About half of the students we interviewed had some understanding of how to report safety or ethical concerns within their school or organization. However, the rest reported that they did not feel equipped to handle these kinds of circumstances and had no idea who to turn to inside or outside of their organizations for help in ethically murky situations.

The study highlights the critical deficiency in engineering education at preparing students for ethical and professional responsibilities in the workplace. Students expressed that their undergraduate and graduate programs overly emphasized technical skills while neglecting professional development, communication skills, and ethics training. We found that these curricular priorities affected students' perception of the culture of academic engineering departments and, subsequently, shaped their own professional values and understanding of engineers' duty to society.

Despite a handful of students viewing ethics as an unnecessary distraction to their curriculum, the majority expressed a desire for more expansive professional and ethics training. This sentiment points to a need for a cultural change in engineering education and workplaces, to bring public welfare and ethical considerations front and center.

Specifically, within engineering education programs, there is a clear need to integrate ethics and public welfare considerations into the curriculum [9], [20], [21], [22]. This should include not only theoretical discussions about ethics but practical case studies and real-life scenarios that engineers may encounter in their professional lives. Additionally, departments should emphasize development of professional skills like communication, teamwork, and ethical decision-making in their curricular assessments [13], [23], [24]. Most importantly, academic institutions need to foster a culture where ethical considerations are seen as integral to engineering problem definition and design of solutions. Faculty and administration need to demonstrate their appreciation and commitment to these values as students learn rules of conduct from their instructors, mentors, and peers. Across the engineering profession more broadly, there is a need for stronger emphasis on ethical standards of practice, including clearer protocols for reporting unethical situations and support for whistleblowers. Engineering professional societies could play a more prominent role in disseminating such guidelines, as well as encouraging their members to participate in ongoing professional development and ethics training.

Our findings also underscore the necessity of increased public awareness and vigilance about the ethical implications of engineering advancements, especially as it relates to AI. As these technologies become increasingly common in healthcare, government, law enforcement, finance, education, and other sectors of our lives, policies and regulations will need to adapt accordingly, informed by engineers who both understand the technical nuances and have strong training in ethics and public welfare concerns [25], [26].

This study has several limitations; notably, all participants were drawn from a single academic institution, and our response rate was approximately 12%. Nonetheless, given our deliberate effort to interview a diverse group of students encompassing a wide range of ethnicities, ages, countries of origin, gender identity, undergraduate institutions, religious backgrounds, and ECE sub-disciplines, we believe our findings offer a broad perspective applicable to the wider field of master's level engineering education in the United States. Overall, these findings call for a concerted effort to redefine and reemphasize the role of ethics in engineering education and practice, ensuring that engineers are not only capable of building the technologies of tomorrow but take responsibility for designing them in ways that benefit society.

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