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Work in Progress: STEMtelling as a Method towards Ethical Awareness in Machine Learning

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Abstract

The recent surge in artificial intelligence (AI) developments has been met with an increase in attention towards incorporating ethical engagement in machine learning discourse and development. This attention is noticeable within engineering education, where comprehensive ethics curricula are typically absent in engineering programs that train future engineers to develop AI technologies [1]. Artificial intelligence technologies operate as black boxes, presenting both developers and users with a certain level of obscurity concerning their decision-making processes and a diminished potential for negotiating with its outputs [2]. The implementation of collaborative and reflective learning has the potential to engage students with facets of ethical awareness that go along with algorithmic decision making – such as bias, security, transparency and other ethical and moral dilemmas. However, there are few studies that examine how students learn AI ethics in electrical and computer engineering courses. This paper explores the integration of STEMtelling, a pedagogical storytelling method/sensibility, into an undergraduate machine learning course. STEMtelling is a novel approach that invites participants (STEMtellers) to center their own interests and experiences through writing and sharing engineering stories (STEMtells) that are connected to course objectives. Employing a case study approach grounded in activity theory, we explore how students learn ethical awareness that is intrinsic to being an engineer. During the STEMtelling process, STEMtellers blur the boundaries between social and technical knowledge to place themselves at the center of knowledge production. In this WIP, we discuss algorithmic *awareness,* as one of the themes identified as a practice in developing ethical awareness of AI through STEMtelling. Findings from this study will be incorporated into the development of STEMtelling and address challenges of integrating ethics and the social perception of AI and machine learning courses.

Introduction and Background

Ethics in artificial intelligence (AI) is a broad multidisciplinary field that aims to address significant challenges that are associated with the development, application, and influence of AI systems. Due to its convergent nature, its effects are far reaching. Its impact can be observed across policy-centric matters of security, bias, privacy, transparency, and environmental impact [3], as well as more philosophical inquiries of what it means to be human, and what it means to live a good life [4].

Undergraduate engineering programs maintain a unique position within the web of AI ethics, as they retain the responsibility to train future engineers, as both users and developers of artificial intelligence. The 2022-2023 Accreditation Board for Engineering and Technology (ABET) handbook details the criteria for evaluating college and university engineering programs and describes the ethics related student outcome as: “an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts” [5]. This particular outcome emphasizes the prevailing importance that ethics has in a wide variety of settings and industries that engineers are trained to work in.

A tension in teaching both engineering practices and ethics is that they are often presented as two opposing ways of teaching and learning content. At the forefront of contemporary engineering education is a focus on teaching engineering as a technological and analytical practice. On the other hand, ethics education emphasizes a different approach that reflects cultural, social, and personal values that often lack a single, linear answer. Presenting ethics as the scrutiny of binary decision-making and moral conundrums oversimplifies how engineers and varying stakeholders make choices.

Engineering decision making involves competing values, trade-offs, and situated nuances that require critical reflection rather than a rigid adherence to good or bad pathways [6]. In this sense, ethics is not a step in the engineering process. Rather, ethics is embedded and negotiated in the design of the entire system [7]. Positioning contemporary ethics as a magical response to ensure that all engineering problems are responsible and moral, reduces the notion of "ethical considerations" as a means to a logical end.

Varela [8] argued that in the modern world, "Moral philosophy has tended to focus on what is right to do, rather than what is good to be, on defining the condition of obligation rather than on the nature of a good life (p. 3)." Telling students how to think or the correct ethical way to reason, does little to prepare them for making their own decisions or for professional responsibilities they will encounter. When considering the use of AI, the distance between the inputs or prompts, the opacity of algorithms involved, and the outputs further exaggerates these problems. AI obscures the challenges that would typically emerge when forming judgments of the social and ethical implications of designing systems architecture [9]. Consider social media recommendation systems or ranking algorithms, which are designed to amplify certain types of content. These often catalyze the spread of misinformation or bolster processes of political polarization, while creating the illusion that these outcomes are purely technical and not driven by human decision making.

Ethical Awareness, Narrative Practices and Machine Learning

Varela goes on to say that,"Ethics is closer to wisdom than to reason, closer to understanding what is good than to correctly adjudicating particular situations" [8, p.3]. If wisdom is a critical practice of ethical awareness then how does one teach wisdom in a machine learning course? To answer this question, we argue that storytelling can foreground wisdom by presenting complex experiences that reveal practical insights of ethical awareness. Building from Varela's philosophy of ethics as a practice of wisdom — we define ethical awareness as a cognitive, reflective, and collaborative process that requires both emotional sensitivity and rational knowing, often emerging from an individual's interaction with their environment, prior experiences, as well as understanding the experiences of others. From this standing, stories can act as a means to bring these ethical tensions into the forefront and break down complex moral challenges into more relatable and memorable moments. Narrative practices make the invisible noticeable and the noticeable experiential. Additionally, the more objective structure of machine learning systems and processes cannot be fully understood through linear thinking. Instead, narrative is essential for engaging with complexity, because narrative allows for individuals to make sense of non-linear, emergent, and context-specific phenomena [10]. In relation to machine learning, storytelling can illuminate otherwise black boxed processes [11]. Hersh [12] further relates this point to narratives, "Ethics and ethical decision making are often treated as discrete actions and decisions rather than the processes which are embedded in systemic structures. Narrative ethics is one of the approaches which stresses the importance of systems and processes" (p. 328).

The use of narrative to explore ethical relationships with machines is not new. After all, Isaac Asimov [13] introduced the three laws of robotics in the short story *The Runaround.* The three laws of robotics were primarily taken up as a literary device to examine the ethics of human-robot behavior in many of his writings. In engineering education, science fiction has continued to be a place to explore the unknowns of new technologies [14]; as an entry point to discuss ethical frameworks in disciplinary subjects [15]; and for ethical sensemaking in an engineering design course [16]. Beyond science fiction, narratives in engineering education are most common in case

study pedagogy to explore real world implications of technologies [17] by examining ethical dilemmas in both generalizable and exceptional occurrences.

Moving beyond other peoples' stories, we explore STEMtelling, a structured storytelling method/sensibility [18]. STEMtelling offers a method for students to learn ethical awareness, both as an AI user and developer, by leveraging the subjectivity of their lived experiences and interests. This is crucial, as engineers often rely on the subjective knowledge to form decisions during the engineering design processes, while collaborating with others, and as a sense making practice. [6]. To explore how STEMtelling supports student integration of ethical awareness into their conceptualization and development of AI technologies, we ask the following question: How does STEMtelling influence students' understanding of ethical awareness of artificial intelligence?

Frameworks, Methodology, and Study Design

STEMtelling Framework

STEMtelling is based in Helen Longino's requirements for social epistemology [19], [20]. Longino proposed that a goal of social epistemology is to reach consensus through critical discourse from a plurality of perspectives achieved through idealized epistemic practices. These epistemic practices include shared standards, paths for criticism, tempered equality of intellectual authority, and uptake of criticism. While originally intended for scientists who work in convergent research groups, we have situated the proposed requirements in classrooms that already include a multitude of experiences and expertise that emerge from creating, sharing, and remaking stories.

STEMtelling story prompts were created in alignment with the objectives of the course, thereby anchoring STEMtelling as an integrated activity. For example, one of the learning objectives was to "utilize more advanced machine learning tools such as neural networks" (from the syllabus of ECEG 478, *Machine Learning and Intelligent Systems*, Spring 2025, Bucknell University). The STEMtelling prompt designed to align with the subsequent learning objective was: **"**Author a story about a time when you learned how a technological device or system damaged the environment in a place that you care about." The description that follows is not an exhaustive explanation of how STEMtelling works. Instead, it is a brief depiction to articulate the process:

1. STEMtellers (participant storytellers) write STEMtells (stories) from the STEMtelling prompts.
2. STEMtellers bring their STEMtells and meet in a small group, which is described as an epistemic culture [21]. In their epistemic culture, they read their STEMtells out loud, follow guidelines to produce epistemic practices [19] while having critical discourse around ethical awareness of AI that is illuminated in their STEMtells. Reading out loud is a reflective practice that seeks to support STEMtellers in learning of the different insights that others have. This sharing of stories enables and catalyzes the collective advancement of engineering knowledge [6]. From here, students peer review each other's STEMtells and offer feedback on how to improve the STEMtell.
3. STEMtellers rewrite their STEMtell based on the feedback received in their groups.
4. Step 4 was an additional step and suggested by Author 2, to specifically engage with the context of STEMtelling in a machine learning course. In this Step, students were asked to upload their STEMtells into a LLM of their choice (ChatGPT, Claude, etc.), with the following prompt: "First, summarize each story. Second, assess the quality of these stories and provide suggestions on how to improve the stories based on story structure, sensory details, and other components of a story. Third, provide feedback on how factual the technical information is and how it relates to societal

issues of artificial intelligence." Finally, participants wrote a reflection comparing the feedback received from their peers to the feedback provided from the LLM.

Ethics by Design Framework

To approach ethical awareness through STEMtelling in this course, we employed the framework, *Ethics by Design,* which originated out of interdisciplinary European research networks in Computer Science, ethics, and responsible innovation [22], [23]. The central argument of Ethics by Design, is that technologies *can* be developed ethically when transparency and ethical decision making is part of the design process from the beginning to the completion of AI based systems. Engineering design is a social process that is based on dialogic exchanges that occur while working with others, where design decisions are often indirectly governed by individual values and experiences [24]. The underlying assumption of Ethics by Design is that technologies are not neutral, thereby situating engineers and other actors as a part of the ethical decision making within the whole design process. The European Commission on AI Ethics has since adopted an Ethics by Design approach when designing and developing solutions that are rooted in prevailing AI concerns, such as bias, privacy, transparency, security, and environmental impact [25]. Integrating Ethics by Design into a machine learning course through STEMtelling demonstrates how ethics goes beyond the technical scope of the project to embrace the social characteristics, where stories highlight the importance of whole processes as: on-going, non-linear, and connects to broader concerns of AI ethics. Thus, STEMtelling is focused on building awareness in prevailing areas of concern in the field.

Methodology

This study utilized a case study design [26], grounded in activity theory. In this framing, learning is presented as an active, reflective, and social process within a system [27]. Activity theory was developed to examine how human transformation (learning) occurs from sociocultural interactions between an individual and society that is mediated through tools within an interactive system [28], [29]. Transformations are the result of the interactions based on context, consciousness, and activity being a singular *one* [27]. This is a turn away from viewing learning as a cognitive and individual process and it situates the activity as the basic unit of measurement of transformation. An activity system includes six distinct 'moments' that all contribute to learning. The activity system is not to be considered a sum of all moments, rather it is an interconnected and holistic process of all the moments. In each of these interactions, moments are altered by the mediation of a tool between the subject and the object.

The first component in the STEMtelling activity system (Figure 2) is the subject (the STEMteller). The tools in the activity system are the mediating artifacts, the STEMtells. The members of the epistemic culture (instructors, peers and others who influence the STEMteller) make up the community. The rules and the division of labor support how the activity is directed towards achieving a certain outcome. In STEMtelling, the rules originate from the classroom policies, STEMtelling, course instructions, and the requirements of social knowledge [19], [20]. The object is the production of social knowledge, which leads to the outcome. In this study, the potential outcome is ethical awareness of AI, as achieved through STEMtelling.

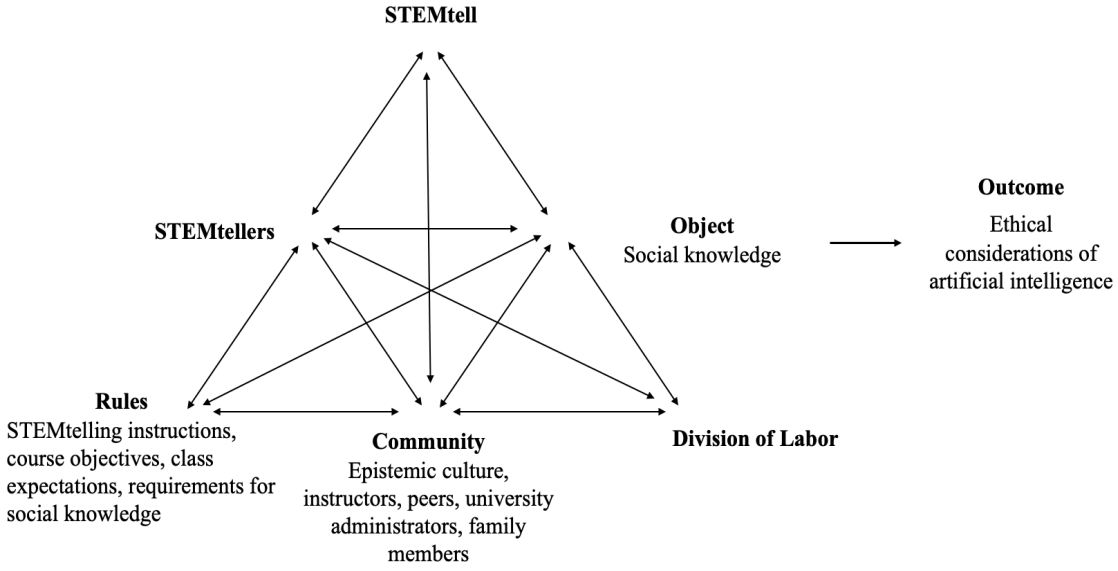

Figure 2: Activity theory model, adapted from Engeström [30] to demonstrate the six moments of the STEMtelling activity system that leads to ethical awareness of artificial intelligence.

Context, Data Collection, and Analysis

STEMtelling was implemented in a semester-long, upper-level undergraduate machine learning course in an electrical and computer engineering department at an elite, private, undergraduate liberal arts institution in the Northeastern United States. The course teaches both theoretical foundations and practical applications of machine learning through readings, lab-like assignments, mini-projects and a final cumulative project. Students are expected to have some fundamental knowledge of Python and to have completed Calculus III as a prerequisite to enrolling in this course. All 34 students enrolled in the course participated in one full cycle of STEMtelling (Steps 1 - 4). The first author implemented STEMtelling. The second author was the instructor of the course. Due to the brevity of this WIP, we are reporting on one theme to respond to the research question. The theme was developed from the written artifacts that were produced in Steps 1 – 4. The first author conducted inductive thematic analysis [31] and identified five codes that contributed to the theme of algorithmic awareness: *knowledge of algorithms, perceived control, critical evaluation, agency and resistance, and moral and political concern*. In the findings and the discussion, we refer to these codes as facets of algorithmic awareness.

Initial Findings

In this section, we examine how facets of algorithmic awareness contributed to participants' learning of ethical awareness that were identified in Steps 1 – 4 in STEMtelling (Table 1). We define algorithmic awareness as an individual's understanding of how algorithms shape, filter, and mediate information, interactions, and experiences that people encounter in digital environments, including recognizing not only the existence of algorithms, but also their influence, limitations, biases, and broader social implications [32], [33].

Table 1: Facets of Algorithmic Awareness Identified in STEMtelling

Facet	Definition	STEMtelling Example
Knowledge of Algorithms	Understanding that algorithms sort, filter, and curate information [33].	"While reading our STEMtells, we saw many similarities - specifically on the accuracy of large language models. For instance, in Xena's story an LLM generated a false report of a medical article, while in mine an AI model incorrectly made predictions based on facial features of individuals. We also saw that we both had similar experiences with data sharing and data access of social media algorithms and mobile applications - where our data was being used without our knowledge to tailor suggestions to our needs." – Rin, describing similarities between her and others' STEMtells in Step 2.
Perceived Control	Belief in one's ability to influence algorithmic outputs [34].	"When I first joined Snapchat, I kept my location services on, but after a little while, the thought of keeping my location exposed semi-permanently made me uncomfortable, so I turned off my location services to prevent any personal information about my addresses from being traceable*."* —Tanner's STEMtell revision in Step 3.
Critical Evaluation	Ability to question fairness, transparency and bias in machine learning [35].	"As I wrote a prompt asking it to generate an image of me, I expected a neutral or ambiguous result as it only knew my name as Kelly. Instead, it created a picture of a man. At first, I laughed. Then, I thought about why this happened. Nowhere had I mentioned my gender, yet the AI had assumed I was male. Was it because I study engineering? Because I code? Because I work with embedded systems and study programming languages? Probably. Yes duh." – Maya's STEMtell in Step 1.
Agency and Resistance	Strategies that people use to game, resist, or circumvent algorithmic systems [35].	"I would not use ChatGPTs feedback because it, to me, is without a lot of substance. I could feed it a lot of information about me, but why would I give it more than I have to? It also allows me to retain some level of agency in a world that is continually becoming more and more dependent on AI to do tasks because we just think about productivity." – Sunil's reflection in Step 4
Moral and Political Concern	Knowing broader societal consequences of algorithmic governance [36].	"After doing this activity, I have been thinking more about how AI fits into everyday life and the choices we make. Before, I saw AI as mostly a tool that just responds to prompts, but now I realize how much it shapes what we see and how we think. Whether it is targeted ads, recommendations on social media, or even misleading summaries, AI is influencing us all the time." – Alex's Reflection in Step 4

Discussion and Next Steps

In this study, we argued that STEMtelling became a practice of ethical awareness when integrated into a machine learning course. By focusing on different facets of algorithmic awareness, we were able to tease out how STEMtelling facilitated ethical awareness. STEMtelling helped students not only recognize the presence of bias, lack of transparency on how their data was being used, privacy and security implications, and impact on the environment but also reflect on their personal roles and agency within these contexts. Allowing students to not solely relate to machine learning and AI as deterministic technologies, but as social constructs that often produce ethical conundrums, established ethical awareness. Participants discussed and wrote how algorithms function in a broader social context in *Knowledge of algorithms,* demonstrating an understanding that goes beyond mere technical and practical know-how. They narrativized how they would modify and adjust parameters to hide their search history, location, and other privacy settings as a practice of *Perceived Control* over algorithmic influence in their day-to-day life. Through *Critical Evaluation,* participants questioned the outputs that their interactions with AI produced, including, but not limited to, algorithmic hallucinations, biased outputs, or algorithmic slop. In *Agency and Resistance,* students wrote stories of refusal to use AI for certain tasks, a mistrust in the ability of AI, especially when AI interfered with human creativity and agency. Finally, participants voiced *Moral and Political Concern* when noticing the less obvious ways that AI is integrated into our lives. Each facet was more salient as students were drawing, sharing, and reflecting from their own interests and experiences, including writing about friends, and family — highlighting relationships and experiences that mattered to them. The nature of STEMtelling, created an environment of relatability and transparency, further establishing visibility that ethical issues in AI exist for us all and occur in our everyday interactions. When examining the environment of STEMtelling, we found that no one step was more important than another. This illustrated how transformation occurred due to all moments in STEMtelling– where ethical awareness is a creative, reflective, collaborative, and iterative process. This supports previous findings of a study of STEMtelling conducted in an undergraduate Environmental Science [37].

At the time of writing, 3/4 of the data had been collected. Results from the pre-survey and post-survey were not included in this work-in-progress because the post-survey had not yet been administered, as the course was still ongoing. This can limit our understanding of how participants' views and experiences of ethical awareness in AI and machine learning evolve through participation in STEMtelling. In the next steps, we plan to conduct a second round of coding and further develop our understanding of how participants' views and experiences of ethical awareness in AI and machine learning evolve through participation in STEMtelling. We will also expand on the themes identified through STEMtelling and assess the strength of each theme. We plan to present a full paper on this study of STEMtelling at the ASEE conference in 2026.

We conclude our work in progress, by returning to our inquiry of *how one teaches wisdom in a machine learning course.* Varela [8] emphasizes that reflection is connected to the embodiment of both actions and perception. This parallels Vygotsky's argument that the dialectical nature of consciousness and material reality are not separate entities. Instead, reason and problem solving originate from both. In STEMtelling, wisdom was exercised by students' advancing algorithmic awareness, thereby helping individuals to recognize where and how tensions occur in algorithmic systems and demonstrating that wisdom begins with *knowing* that ethical tensions *exist.*

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