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"It Can't Tell You How to Do That." Suggesting a Faculty-Focused Subgenre of Instructional Writing

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Abstract - As we prepare new engineers to take on the fourth industrial revolution, engineering faculty are tasked with selecting, learning, evaluating, using, and teaching new technologies to apprentice engineers. To understand how these important tasks are being achieved, 21 engineering faculty members in a STEM-focused Midwest US university were interviewed. Engineering faculty showed an awareness of the rhetorical power of manuals and other instructional resources. Unfortunately, these resources are often inadequately designed to meet the unique needs of engineering faculty. In this paper, we propose that there is an exigency for a faculty-focused subgenre of instructional writing which addresses the needs of engineering instructors who teach students how to use technology while simultaneously learning how to use it themselves. Because of the overwhelming roles that faculty perform, we propose that the composition of this sub-genre should be the duty of technical writers who work closely with technology developers and engineering faculty. We forward that such a subgenre may find space in digital and non-digital learning resources through the inclusion of both the technical information necessary to use the technology, as well as pedagogical tools and activities to support student learning. These materials should be released in accordance with technology updates to ensure faculty are best positioned to teach the most current technologies. The proposed faculty-focused instructional writing subgenre may have implications beyond engineering education, because the need for learning resources may not be unique to engineering faculty, and likely exists for all university faculty learning and introducing new technologies within their courses.

Index Terms – Engineering education, industry 4.0, instructional writing, technology adoption.

INTRODUCTION

Among other things, industrial revolutions mark profound shifts in how human societies are organized, how things are produced, and how we value things [1, 2]. The first industrial revolution was initiated by the invention and proliferation of the steam engine which contributed significantly to the social transition from farming to manufacturing. There are many scholars who believe that we are in the initial stages of a fourth industrial revolution or industry 4.0. To them, this revolution will rely on green energies, metaverses, big data, fintech, and other network/digital dependent technologies, to shape our experiences of the world. For our purposes, the most significant feature of industry 4.0 is the exponential, rather than linear, growth and evolution of digital services, industries, and technologies [3, 4]. For the engineer, this means that technologies of the fourth industrial revolution are also evolving at an exponential rate that is difficult to track. Instructors who are tasked to teach these ever-changing technologies have to take up roles that may make technology adoption burdensome, including testing for usability, developing instructional materials, and teaching the technology as they simultaneously learn to use them.

Developing an understanding of what motivates and hinders faculty in their adoption and teaching of new technologies will result in new interventions that may result in faculty who are nimbler at acquiring and teaching new technological skills. To understand this, we framed our qualitative research project, interviewing engineering faculty about technology adoption, within the Technology Adoption Model (TAM) [5] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [6]. In this paper, we assert that if engineers are going to keep learning and adopting new technologies, they will need the assistance of technical communicators who should be trained to compose a subgenre of instructional writing - a genre that is just as flexible in evolving as the technologies with which they will co-emerge.

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THEORETICAL FRAMEWORK

Much of the work on modeling technology acceptance and adoption emerges from information systems research. Because it is simple and easy to apply, TAM and its revised version, TAM2 [7], are the most widely applied of these models in educational research to determine what motivates instructors to adopt new technologies [5]. Within the TAM, motivation to adopt a technology was linked to two major constructs: the perceived usefulness of the technology, and the perceived ease of use of the technology. Unfortunately, TAM2 is limited in its applicability as it fails to account for the variability that may persist in a person's intention to adopt a technology [8-12].

Seeking to improve on TAM2, constructs from the Theory of Reasoned Action [13] and Theory of Planned Behavior [14] were combined to create the Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT was further revised to UTAUT2 [15] which includes, among its new constructs, facilitating conditions. Facilitating conditions are perceptions that potential adopters of a technology have about the resources and support available for adoption. Within this paper, we focus on what facilitating conditions are available to engineering faculty adopting new technologies as they strive to perform multiple roles that the growth of industry 4.0 have placed on them.

Examples of facilitating conditions may include tech support and other learning resources like manuals and textbooks. In our study, we determined that facilitating conditions may be categorized as digital, non-digital, temporal, human in nature (peers and mentors), or classes. The digital resources include online resources like YouTube and help files, while non-digital resources included manuals and textbooks. Time as a resource is bound by faculty time constraints and pertains to how much time faculty needed to learn a technology, and the time needed to teach it in the class. People who may guide and share their knowledge of a technology also facilitate technology adoption by acting as a learning resource for others. Faculty also often used classes and formal training as a resource for learning new technologies. These facilitating conditions were not originally part of either TAM and UTAUT. They were conceptualized as part of the initial findings of this study.

METHODS

In order to understand what factors influenced our participants as they made decisions to adopt new technologies, this study followed a qualitative approach. In the following sections, we will present information on our positionality as researchers, the participants, the data collection and analysis procedures and the limitations of the study.

I. Postionality statement

Both researchers work in the university that served as the site of the study. One of the researchers is a professionally trained engineer who spent some time in industry before moving to academia. Their research in engineering education and their experience within industry and academia may have an influence on the analysis of the data and the discussion of the results. The other researcher is a PhD candidate whose research focuses on the literacy demands of the 21st century on engineering students and faculty.

II. Participants

21 participants were recruited through email solicitation for this study. These participants are engineering faculty at a STEM-focused Midwest university in the United States of America. The 21 members were recruited using a purposive sampling method where they had to satisfy the singular criterion of being engineering faculty. The participants come from diverse backgrounds and have different levels of experience teaching engineering. Although we cannot claim that the participants are representative of the populations they are drawn from, there was a deliberate attempt by the researchers to have a blend of TT and NTT faculty, different gender identifying faculty and faculty at different stages of their careers.

Of the 21 participants, 7 self-identified as female, while 14 self-identified as male. Career position and progression-wise, 8 participants were NTT, and 13 were TT faculty. In total, 5 of the participants had spent less than 7 years as faculty, 11 had been faculty for 7-14 years, and 5 had been faculty for more than 14 years. Of these, only two had served as either chairs or deans. Since the technologies faculty use may be influenced by industry, we were interested in knowing how many of the participants had spent time in industry. Of the 21, 4 had no industry experience at all, 6 had less than 5 years, 7 had worked between 5-10 years in industry, and 4 had had more than 10 years of experience in industry.

III. Data collection and analysis

Each participant was interviewed once for the study. Thus, a total of 21 interviews were conducted via zoom. Each interview lasted for about an hour. These interviews were transcribed using a denaturalized approach [16] that first involved using Zoom's transcription feature to produce an initial transcript. The initial transcript was then proofed by the researchers by correcting obvious spelling errors, noise, phonological and other paralinguistic speech features. A denaturalized approach was used because this approach emphasizes the meanings that are made and negotiated between the participants of the interview. The research interest was focused on the factors that increased the chances of a technology being adopted. There was no research interest in linguistic/discourse characteristics like accent, stress and prosody. After transcription, the data was analyzed by the researchers using multi-pass convergent coding [17].

IV. Limitations

While the results of the study are significant to technical communicators and engineering educators, the study is limited by the following conditions: (1) only engineering faculty at one university were interviewed. There may be conditions that differ in other universities (2) Interviewing 21 faculty members cannot give a complete representation of what it means to have or not have access to conditions that facilitate the adoption of new technology.

RESULTS AND DISCUSSION

The preliminary results of the analysis indicate that facilitating conditions play a major role in predicting whether an instructor adopts a new technology or not. Table 1 presents a summary of the frequency of codes within facilitating conditions.

TABLE 1. FREQUENCY OF CODES WITHIN FACILITATING CONDITIONS THEME

Code	Number of Occurrences	Number (and %) of Interviewees
Peers, Mentors, & Students	167	21 (100%)
Digital Resources	136	21 (100%)
Time	127	20 (95%)
Non-Digital Resources	63	20 (95%)
Classes	95	19 (90%)

This paper highlights the problems and limitations that faculty identified as tied to these facilitating conditions. The problems and limitations, reveal an exigence for a new kind of facilitating condition that is characteristically tied to industry 4.0 and possesses the same kind of features as the technologies whose adoption they facilitate.

In relation to peers, mentors, and students, faculty often discussed learning how to use laboratory technology or software or programming languages for their research from others - either advisors or lab mates (other students) or coworkers in industry. In the quote below, the participant explains using their advisor as a resource to learn a technology when stuck, but also the limitations of relying on peers and mentors.

> F1: I think that from your faculty advisor, you can only get answers to questions that you bring at the moment. Your faculty advisor always has limited time so it's like on my Tuesday at 1:30, wherever I was at that moment; whatever problem brought them, they helped me that far. But then, like, Thursday at four, or whatever, like, 10pm, when you're not able to meet with somebody right then, and you're like digging into help files and then you … have more time and you can dig around more broadly, and so [it's] more time intensive but just, like, more range of material available. [F1]

Two kinds of limitations are presented here. First, the participant points to limitations that humans have -- what a person knows about anything is finite, and they cannot predict what has not been brought up in discourse. Furthermore, humans are limited by their ability to access others and be accessed by others. In this instance, the nature of social interaction determines that a learner may not be able to access this resource at certain times of the day. If faculty are to be prepared to learn the technologies of the fourth industrial revolution, they cannot be solely reliant on peer networks to teach them how to use those technologies.

While digital resources proved to be a trove of information for faculty, participants pointed out that their usefulness were limited because they were especially difficult to understand when it came to assistance with debugging code:

> F12: So, one of the biggest problems that we ran into was the tool set itself. So, the compiler and the other tools in the chain gave the worst error messages in the world. They were so bad, so there was a, the actual tool that you would call on the command line was called NC Verilog. The errors were so bad that they shipped another tool called NC Help, where you took the error codes from the compiler, gave them to NC Help, and then it would explain to you what the error code meant. [F12]

Many of the existing digital resources for learning technologies were developed based on modes of thinking and learning prior to the 4th industrial revolution. As such, they do not provide adequate support for those acquiring digital skills during the digital revolution. Situations like this can be improved if industries pay attention to how their technologies communicate with their human users - a problem that properly trained technical communicators can resolve.

Furthermore, faculty pointed out that typical of an industry 4.0 context, there were a lot of online resources available to aid the adoption of new technology. The problem was that a lot of this information is not curated, so most of it is not useful to them.

F2: There is such a large body of both useful and unhelpful stuff that it's almost difficult to sift through all of it to find what is the thing that will help me solve my problem. [F2]

In the end, as one faculty member pointed out, whether the facilitating conditions are digital or non-digital, temporal or human, there is always something that it cannot tell how to do.

If you're getting the instruction manual for it, it's just going to tell you what the buttons do, where things are located, and then you're going to have some data, some information, that you're going to want to get things out of. It can't tell you how to do that [F17]

Or in cases where the technology is relatively new, the resources to aid adoption just do not exist.

F6: I think the difficulty was that I couldn't find tutorials to do what I needed it to do. I had a really hard time finding it for Julia. Julia is a little bit of a newer programming language. And for what I needed it to do, I couldn't find resources. And so basically I was time constrained. I needed to do what I needed to do quickly. And so I was willing to put in a day to try and figure it out [F6]

The data suggests that the demands of industry 4.0 require engineering instructors to become support-content creators as they go about the task of teaching new technologies. This becomes increasingly difficult as the technologies exponentially increase and evolve, the materials that the instructors use to teach become obsolete at the same pace. For example, one faculty member mentioned using a software which issues updates annually. Thus, some faculty indicated that when they consider the amount of time it takes to create new tutorials, and the amount of time it takes for those tutorials to become obsolete, there is no point in adopting the new technologies until they become relatively stable. For example, this faculty says that changes to software is one reason why faculty refuse to teach new ones.

F11: The tutorials we developed and there's a lot of infrastructure around it. And it's hard to change and part of the reason why faculty in general don't like teaching software is because it changes. You say I want students to learn the software this way, and you make a tutorial, and then the interface changes, and then that doesn't work anymore, and you got to redo it. And you know that I guess that that's going to be a difficult process so that's why I tried to rely more on using vendor materials and working with software suppliers where even if there's some aspect of a tutorial that I wanted to do, I'll ask them to do the tutorial. And you know, we have 1400 mechanical engineering undergrads and they said we'll teach them all the software. So they have incentive to work with us. So it requires a partnership, you know, and that doesn't always work for some faculty to stay on top of that, and it takes a lot of time. And the course you know the course can't ever really be wrote, because it's updating and evolving all the time. [F11]

This participant gives us a clue to what a new instructional genre that arises in the fourth industrial revolution should look like. Unlike current instructional materials, their authorship should involve a partnership between instructors and the creators. Furthermore, they should be flexible enough to be able to evolve just as quickly as the software.

The limitations that the data highlight lead us to the conclusion that even though we are in the midst of a new industrial revolution, most of our facilitating conditions - digital and non-digital learning resources - have not been adequately adapted for the new and faster paced modes of learning and sifting through large amounts of information. What engineering faculty need is a facilitating resource with the following features: (1) it must co-emerge with its technology and not arise as an afterthought; (2) it must be as easily updated as the technologies whose adoption they facilitate; (3) it must communicate with users in a clear and understandable manner; (4) it must include pedagogical materials that allow faculty to work within the time constraints that they have.

CONCLUSION

Industry 4.0 is changing the way faculty receive and adopt new technologies. As facilitators of the adoption process, engineering faculty need help. Recognizing that there is an exigence for a different form of technical communication is one of the steps that can be taken towards addressing the problem. Some of this help must come from technical communicators who would construct these materials and their training should make them aware of the different demands that the 4th industrial revolution is making on engineering education. There must be technical communicators on site whose works are part of the evolution of technologies, so that updates to technologies arrive with updates to facilitating conditions. These conditions should include pedagogical materials that will aid faculty to perform their complex roles as have been determined by industry 4.0.

The role of technical communicators and writing faculty in engineering education must be completely rethought. If a genre of instructional writing that facilitates the adoption of new technologies in industry 4.0 is to exist, it must address new and novel ways in which technical writers will work with engineers and innovators. Technical communicators should no longer be seen as service providers, but should be seen as partners in the innovation process [18]. The same can be said about the place of technical communication programs in engineering education. Academic silos must be reduced and technical communicators recognized as an integral part of communities of practice with engineers. This may relieve some of the time pressures that engineering faculty have as they try to find or produce instructional materials. Since industry 4.0 entails energy efficiency, this new genre of instructional writing will reduce redundancies that arise from many educators across many universities doing the same work in producing tutorials and other instructional materials.

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