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Teaching Deficiencies of Crucial Literacy Skills within STEM Education

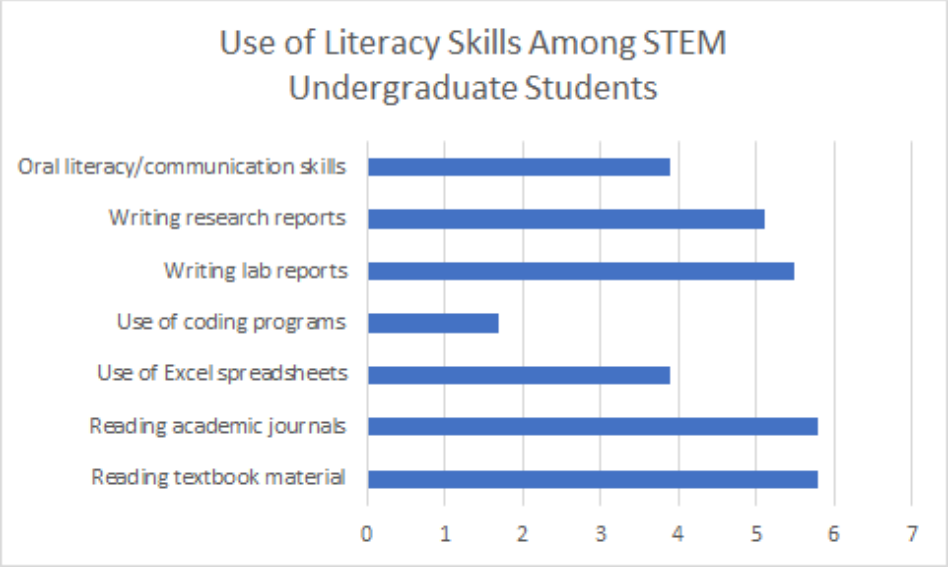
STEM is a massive area of study spanning science, technology, engineering, and mathematics. Because of the scope of this field, an extensive amount of research goes into improving the education of those aspiring to work in it. This research is necessary and meaningful, as the Boyer Commission Report has found that "the failure of research universities seems most serious in conferring degrees upon inarticulate students" (Bayer & Curto, 2005, p.11). Research has been performed in hopes of both improving the quality of undergraduate education for STEM students and the retention of students within STEM education, as there has been a decrease in students majoring in STEM and STEM undergraduates progressing to graduate school (Fairweather, 2008).

In addition to the declining numbers of STEM students registering in graduate school, many STEM students entering the work field leave their careers early on, especially those belonging to marginalized groups (Suchman, 2014). Research has suggested that this can be accredited to gaps between most students' experience with STEM education and the changing expectations of the job market throughout several studies (Jang, 2016), however, this must be verified through further analysis. Additional research will provide insight into what skills new STEM graduates are lacking, why they aren't learning these skills, and how we can introduce them into the curriculum.

This article will not only explore any discrepancies between what literacies STEM students are taught and which they're expected to know by employers, but also other flaws

within STEM education, such as teaching deficiencies, and the reason why fewer students are entering STEM majors and remaining in the STEM field. It will also explore the importance of specific literacy skills that appear to be lacking in traditional STEM education, such as soft skills and public speaking, and tools that could help reengage students within STEM and increase retention rates, like undergraduate research experience.

In order to examine these research questions, I conducted a survey within undergraduate STEM students assessing the literacy skills they believed they used in their undergraduate education, and to what extent, in order to compare these results with the research collected of the skills sought after by employers in the STEM field. I also contacted one of the Ph.D. students researching in the lab I work in and asked her a few questions related to the skills she was taught in undergrad compared to the skills she needed for her postgrad and Ph.D. research, as well if she feels her education prepared her for the expectations she's held to by her career.



There are a multitude of articles documenting the skills that employers look for in new hires, both in the general workforce and in STEM specifically. In an article by Hyewon Jang published in 2016, experts found that five skills that are becoming progressively more important

within the STEM workplace are adaptability, complex communication skills, non-routine problem-solving, self-management, and systems thinking. In another study by Margaret Andrews, recruiters from over 600 companies reported that the skills in today's job market that are the most desired and hardest to find are communication, leadership, problem-solving, and strategic thinking (2015). This can be heavily contrasted with the results I received from the undergraduate survey I conducted, which found communication skills among the three least used literacy skills.

Technical knowledge being prioritized much higher than communication and other soft skills in college, and much lower than communication in the workforce, was a trend I noticed throughout several of the studies I researched. In an article by Anne Sabine, only 6% of employers found high academic achievement to be essential, while skills in collaborations were considered essential by 60% (2019). A study from 2009 found that of surveyed alumni, 55% found that the most difficult situations at work were listening, formal presentations, and problem-solving, and 62% needed to use speaking skills almost constantly (Johnson & Szczupakiewicz, 2009). Another observation made was that adaptability was considered both essential and one of the skills that new graduates lack the most (Sabine, 2019).

In Hyewon Jang's study, she analyzed job databases to investigate the job qualifications listed for STEM jobs, in comparison to others. She found that STEM employees require greater critical thinking and problem-solving skills than those in other professions, due to their need to be able to solve complex math and science problems. She also found that interpersonal skills are highly important in all STEM work (2016). Another skill that was found to be highly valued by employers in several studies was self-efficacy in research (Adedokun et al, 2013). If a student can learn self-efficacy during their undergraduate education, it greatly increases both their

research skills in the workforce and their ambition to continue within the STEM field. Self-efficacy skills increase with positive experiences in a given area, so providing students with research experience during their undergraduate education can help them considerably in developing these crucial skills (Adedokun et al, 2013).

In the interview I conducted with Saarah Kuzay, the Ph.D. student in my lab, I asked her about the skills she learned as an undergrad, and if these were different than those she uses in her daily work life now. Among those, she listed skimming textbooks and journal articles, memorizing and summarizing information, and writing reports. Contrarily, the skills she uses in her research and Ph.D. classes are team coordination and management, developing her own protocols and directions, and learning how to be adaptive and flexible. She noted that the main differences between her learning through undergraduate courses at UC Davis and her learning through her research and post-undergraduate education are that "now my learning is largely self-guided and exploratory compared to the prescribed/directed learning," and "people management is the largest new skill I had to acquire; group projects don't address this skill." Interestingly, her entire response to this question directly supports the claims of the articles I'd been researching on the topic, listing self-efficacy and soft skills such as teamwork and adaptability as some of the skills she was using most in her work.

Overall, several trends can be observed through all this data. What researchers have found is that, most prominently, STEM graduates are not receiving the communication and interpersonal skills they need at the level that employers expect, and these are by far the skills that recruiters seek most. Other common skills that were lacking in STEM graduates throughout multiple studies were leadership, adaptability, and self-efficacy. If professors can implement programs for larger numbers of STEM students that give them firsthand experience in these

skills such as internships or work-study jobs, introduce these skills into the undergraduate curriculum, or at least emphasize their importance prior to graduation, this could improve the readiness of incoming graduates into the workforce and promote retention of STEM students in their education and throughout their careers.

One of the main causes of the decrease in STEM students enrolling in graduate school is poor teaching practices. This has already been well researched and documented, however teaching reforms that have been created as a result haven't produced many results. Many studies believe this is because there is a great misconception among professors that allocating more time to teaching pedagogies has a negative effect on the quality and amount of time spent on research (Fairweather, 2008). In order to enhance the experience of undergraduate students in STEM, teaching must be improved. One method that has been suggested is to include STEM students in research experiences. Undergraduate research experience within STEM is linked with increased STEM retention, higher graduate school enrollment rates, and increased bachelor's GPAs. It has also been found to lead to higher intellectual curiosity and better professional writing, research & academic skills, and communication (Feldon et al, 2016). Other observations that have been made while studying the faults of undergraduate teaching are that many introductory STEM courses are taught by part-time or temporary professors, even though these are some of the most important classes for undergraduates, and that professors that utilize active teaching styles achieve greater student success (Suchman, 2014).

Several solutions have been proposed to reform STEM education and improve STEM learning experiences. Most of the current STEM teaching reforms focus on increasing student learning, however, there is much more that can be done to improve the system. Some potential methods are increasing STEM awareness to the public through outreach, as well as using

outreach to improve the K-12 STEM pipeline in all schools. It would also be beneficial to increase the amount of career preparation taught to students during school, both in the form of information and general mentoring, as well as teaching and exercising practical skills necessary in the workforce (Fairweather, 2008). In my interview with Saarah Kuzay, she mentioned, “Most UCD courses are indirectly training students how to be good students, not mature thinkers or learners… Generally speaking, [this]... [does] not serve a person well outside of a classroom environment.” Shifting emphasis in universities from “hard skills” to “soft skills” could greatly benefit the future careers of its students.

Since oral literacy and good communication skills are some of the most crucial skills from the perspective of employers, public speaking classes would presumably be a core component of STEM curriculum. However, a survey conducted by an oral communication lab found that 49 out of 68 students in a biological sciences writing class had never taken a course or workshop in public speaking, and many of these students showed great discomfort towards the thought of public speaking (Bayer & Curto, 2005). It’s important for STEM students to learn the oral literacy skills they’ll need for the professional world during college, however, the synthesis of complex material into information that can be delivered in an easily consumable format is a skill that many college students lack.

In another study on public speaking in STEM students, it was found that there were large differences between the percentage of alumni using public speaking skills in their work and the amount of faculty who are teaching them (Johnson & Szczupakiewicz, 2009). This inconsistency could potentially explain the lack of retention and issues of students leaving the STEM field early in their careers, as students are sent into the workforce only to realize that they’re missing an entire crucial skill set. The author of this article recommended that a mandated two-semester

public speaking course teaching work-related skills is implemented in universities. When I asked my interviewee Saarah her thoughts on public speaking in her field specifically, she said, “Good public speakers and presenters can use language artfully to talk at a high level while being accessible, engaging, and tailoring their content to specific audience types.” I believe STEM undergraduate students could greatly benefit from exercising some of these specific oral literacy skills in public speaking classes and workshops, which currently are lacking in the curriculum.

Another trend I saw in the research I did was that soft skills are some of the most sought out skills by employers in recent years. A study in 2014 found that employers see hiring individuals with soft skills such as communication as crucial to company success (MacDermott et al, 2016), yet schools emphasize learning “hard skills” and often neglect the instruction of soft skills (Andrews, 2015). Soft skills are “personal competencies that improve human performance, facilitate effective interactions, and complement the technical requirements necessary to acquire and maintain employment,” and include skills such as communication, self-reliance, teamwork, and leadership (Lee). Technical skills are easier to teach on the job than soft skills (Sabine, 2019), and because of this, soft skills are some of the most sought out and shortest in supply in the job market (Andrews, 2015).

Soft skills are another literacy skill mentioned by Saarah Kuzay in the interview I conducted with her. When I asked if she felt her undergraduate curriculum adequately prepared her for the public speaking, interpersonal communication, and teamwork skills needed to succeed in STEM careers, she stated, “Soft skills are what separate mediocre vs. good vs. outstanding candidates in any job interview. Beyond the job interview stage, these interpersonal skills are what allow people to thrive in a work environment.” Yet, many students don’t even learn what soft skills are or their significance during their undergraduate education, nonetheless get a chance

to practice and improve these crucial skills (Sabine, 2019). This is a clear fault in undergraduate education and further research should be done on how we can introduce these skills to students prior to graduation, as none of the articles I read on teaching reform mentioned soft skills. Personally, I had never heard of soft skills until I started my research for this article and am surprised the topic has so little coverage in education, considering its importance is so widely known throughout the professional world.

As mentioned previously, undergraduate research experience offers considerable benefits to students. In addition to teaching important literacy skills such as data entry, analysis & interpretation, and lab skills, it can also help attract and retain STEM students (Adedokun et al, 2013). In other studies, it has been shown to help students learn and improve soft skills, since students are provided with the ability to interact in the types of situations they'd be faced with in a real work environment (Sabine, 2019). In an article studying the effects of undergraduate research, the students with undergraduate research experience outscored others in all categories but one. The experience is most beneficial when it spans multiple terms, but the students received benefits regardless of term length (Feldon et al, 2016).

STEM is a collection of fields that is crucial for countless reasons. Because of this, ensuring that we're maximizing our efforts to encourage students to enter STEM fields, as well as increase their rates of graduation in schools and improve their likelihood of success in the workforce, is critical. The research I've conducted through this article demonstrates that there are major disparities between the hard skills taught to undergraduates throughout college, and the soft skills so sought after by employers in the job market. The fact that so many undergraduates graduate lacking critical literacy skills could be a potential factor as to why retention of STEM students is dropping and many of those who stay leave the field early in their careers.

This shortage of crucial skills is largely accredited to poor teaching practices, as well as the staffing of important science classes with non-tenured or part-time faculty. There is a surplus of research available on teaching reforms for STEM, as well as articles identifying the shortcomings of current STEM education, including the lack of effective public speaking classes and the instruction and practice of soft skills such as teamwork and leadership. The problem with STEM education is not identifying its flaws, as that has been done. The research is available, yet professors fail to adopt new teaching reforms and pedagogies, likely due to the fact that faculty are paid more for research than for teaching, and those who spend extra time improving their instruction don't receive any kind of compensation. Undergraduate teaching would likely improve if there were greater incentives put into place to reward professors who allocate more time in the classroom.

Undergraduate research experience seemingly provides solutions to almost all of the issues presented previously: it can increase poor retention rates and stimulate interest in STEM career paths, can improve oral literacy and other soft skills that standard classroom education struggles to teach, and introduce students to some of the technical skills they might need in the setting of their given field. In my own experience, I've worked in the Dubcovsky Lab at UC Davis for over a year and often tell people I sometimes believe I'm learning more in the time I spend at work than I do in my classes, through the interactions I have with my bosses and the rest of the people working in the lab, and by getting to physically do some of the things I might be doing in a real fulltime job once I graduate. Unfortunately, there are disadvantages to undergraduate research as well. Primarily, undergraduate research experience is something that isn't available to all students, especially in universities that are smaller and less well-funded. Initiatives to increase the availability of these opportunities, as well as encourage them to

students, could greatly aid in preparing STEM undergraduates to be fully qualified for the positions available in the job market.

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