

# What are biomedical engineering employers looking for in new hires? A Qualitative Synthesis

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**Abstract**—This work in progress research paper describes part of a project that aims to understand what qualifications BME industry employers prefer in the hiring process. An inductive content analysis of 95 job postings relevant to upper-level or soon-to-be graduated biomedical engineering (BME) bachelor's degree students was performed to explore patterns in responsibilities and qualifications within these postings. Results from this work indicate a high emphasis on employees' ability to apply technical documentation and communication skills in the job setting. Codes related to job qualifications indicate industry employers prefer employees with general professional skills that allow them to work in a team setting and solve problems. Additionally, we found that employers are often open to hiring BME majors in addition to multiple other engineering and life sciences majors for the positions listed in the postings in this targeted BME job search. In future work, the results of this content analysis will be used to inform the development of a set of archetypal BME student resumes that will be used in semi-structured interviews with BME industry hiring managers. The interviews seek to examine the alignment between what job postings indicate as important, what hiring managers articulate as important in hiring decisions, and what hiring managers view in resumes as representing those qualifications. The overarching goal of this work is to understand the landscape of BME industry hiring practices and increase alignment in the goals of industry, students, and educators. Results have the potential to inform how students engage with BME education, how they represent their experiences in application materials, and how educators structure BME curriculum.

**Keywords**—undergraduate, biomedical engineering, industry, career choice, qualitative

## I. BACKGROUND

Biomedical engineering (BME) has been recognized as a degree that allows for a broad range of career opportunities upon graduation [1]. However, BME bachelor's degree holders have consistently expressed challenges with identifying and securing career opportunities in industry after completing their degrees [2]–[4]. Generally, educators have attributed these challenges to industry employers' misunderstanding of what the intentionally broad BME education prepares graduates to do [5], [6].

While some programs have had success with creating industry partnerships to address the disconnect between graduates seeking jobs and employers looking to hire BME's [7], more work is needed to understand how to prepare BME students to enter industry careers. Some work has begun to explore what employers in industry are looking for when hiring BME graduates through exploratory interviews or surveys [8], [9], but further, more in depth research is needed to understand the landscape of BME professional practice.

We used Wegner's Landscapes of Practice (LoP) [10] concept to inform this work. The LoP concept describes a field of study as being comprised of multiple communities that have differing practices and recognize competence in unique ways. Additionally, the differences in how communities define practice and competence can create boundaries between the multiple communities within a field. For example, within BME, academic communities may prioritize competencies that are different than the competencies practiced by the multiple BME industry communities of practice. This project uses LoP to examine BME professional practice as multiple BME communities working towards the same goal: solving medical problems using engineering principles and strategies. By looking at BME this way, we acknowledge that academia and industry communities may differ in what knowledge or skills they value and how they define competence within BME. This recognition further motivates the need for educators to work to understand what knowledge is valued and what competence looks like in industry settings.

By understanding what industry expects from BME hires, educators can more effectively adjust curriculum to align with industry needs, encourage students to strategically engage in out-of-class opportunities, and/or improve how BME departments communicate the skills and abilities of their graduates at the boundaries of academic and industry communities. Facilitating more exchanges at the boundaries of academic and industry practices can ultimately improve the experiences of students who are transitioning from being a member of an academic community of practice to a member of an industry community of practice.

## II. METHODS

The work presented in this paper is part of a larger project examining industry perspectives of BME hires to improve the understanding of the boundaries between academic and industry BME practices. The research questions guiding this project are:

- What do BME industry employers notice and value about a BME students' experience as represented on a resume?
- What distinguishes one BME grad from another among BME industry employers?

The work presented here is an analysis of job postings relevant to BME undergraduate students from three databases (LinkedIn, Indeed, and Handshake). Using a systematic search strategy, an initial pool of 135 job postings was identified as relevant to upper-level or soon to be graduating BME undergraduate students (see Table I for search criteria).

An inductive content analysis was then performed to identify patterns in job responsibilities and qualifications [11]. The length of the job postings did not vary based on the database. Therefore, 30 job postings, the first ten from each database, were chosen to develop a codebook. These 30 job postings were coded manually by all three researchers performing the data analysis. After all the three researchers discussed discrepancies and agreed on the definitions and use, codes to describe the responsibilities and qualifications that emerged in these 30 job postings were used to finalize the codebook. The codebook was then applied to the remaining 105 postings to look for patterns across the postings. While coding, 10 of the job postings were identified as not meeting the criteria for inclusion and removed from the analysis, leaving 95 job postings. The remaining postings were examined for patterns of discussion about job responsibilities and desired qualifications. Codes could be applied multiple times within a job posting, but were only counted once per posting in the analysis.

TABLE I. INCLUSION AND EXCLUSION CRITERIA FOR JOB POSTINGS

Inclusion Criteria	Exclusion Criteria
✓ Desire 0-3 years professional experience or be labelled as entry-level. The position can be labelled as a rotational program.	✗ Require degree level above a bachelor's degree (i.e., Master's, Doctoral, or other professional degree).
✓ Contain the term engineering (or some variation) anywhere in the job posting.	✗ Only require an associate's degree.
✓ Contain a form of 'bio' anywhere in the job posting. (e.g., biology, bioengineering, bioelectrical, biomechanics, biotechnology, etc.) and/or a form of 'med' (e.g., medical, medicine, biomedical, etc.)	✗ Be a biomedical technician or other repair focused position only.
✓ Full-Time or Internship Position	✗ Be a university or academic position (e.g., lab technician in a research lab).
✓ Be based in the United States.	✗ Be an international position.

### A. Codebook development

Codes were developed inductively and generally aimed to capture professional personal characteristics (e.g., *adaptable, able to handle pressure and timelines, able to multitask,*

*motivated (go getter), organized and detail oriented, collaborative team player, willing to learn*), contexts (e.g., *regulatory, quality, medical device, microfluidics, bioelectrical, biotechnology / pharmaceutical*), and skills (e.g., *lab, research, clinical, computational, CAD, coding, engineering*) desired for performing the company's work and selecting a candidate for the job. The results section describes the top responsibilities and qualifications from the full codebook.

### III. RESULTS

Forty-four (44) codes were developed to describe responsibilities (40 codes applied) and qualifications (42 codes applied) listed in the coded job postings. We found that most frequently, relevant job postings were internship or co-op positions in areas like R&D, quality, development, and operations. The most common job responsibilities included *technical documentation or communication* duties as well as *quality, design and development*, or *manufacturing* tasks in a team or multi-department, cross-functional setting. Most of the highly cited qualifications also related to work in a team setting, detailing professional skills (e.g., *communication*, collaboration (*collaborative team player*), organization (*organized and detail oriented*), and motivation (*motivated (go getter)*) needed to succeed in those settings. Though not as frequently mentioned, *coding* and *CAD* software familiarity were also discussed in the job postings analyzed. Within those codes, familiarity with *coding* and *CAD* software like MATLAB, Python, and SolidWorks were the most listed programs.

### A. Job Postings in the Dataset

Many of the job postings found in this search were for co-op or internship opportunities. To get an initial view of the types of jobs in our search, we pulled the job titles of each posting and created a word cloud. Common terms listed in the titles of the postings included: Development, Research, R&D, Quality, Operations, Systems, and Clinical among others (see Fig. 1).

### B. Most Common Responsibilities

Many of the job postings analyzed described the role for which they were hiring by detailing the day-to-day job responsibilities of the prospective employee. Multiple responsibilities were named across the job postings that were coded; however, seven responsibilities were commonly named in at least one third of the postings and are shown in Fig. 2. Over



Fig. 1. Word cloud representation of job titles included in the job search.

two thirds of the job postings analyzed mentioned job responsibilities in the category of *technical documentation or communication* (e.g., creation of work plans, standard operating procedures, testing protocols, documentation for quality or regulatory purposes, etc., 65 postings). Additionally, *quality* (42 postings), *design and development* (35 postings), and *manufacturing* (32 postings) were common codes for tasks to be performed. Employers also frequently discussed the need to work with others when listing job responsibilities as evident by the assignment of the *collaborative team player* and *cross-functionality skills* codes to 37 and 32 postings, respectively.

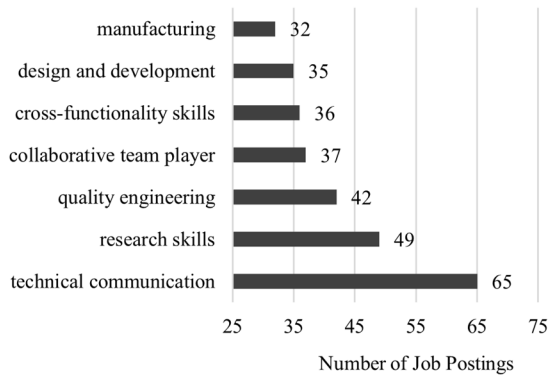


Fig. 2. Top job responsibilities codes applied.

### C. Most Common Qualifications Desired

The qualifications and required skills of prospective employees were also coded using the same general codebook as the job responsibilities. Similar to the ‘responsibilities’ codes, we found that six codes were applied to approximately one third or more of the ‘qualifications’ sections of job postings. Interestingly, the top ‘qualifications’ codes included both professional skills, sometimes referred to as ‘soft skills’, as well as some general technical skills. These top qualifications codes were *communication skills* (56 postings), *collaborative team player* (40 postings), *problem-solving skills* (38 postings), *organized and detail oriented* (36 postings), *motivated (go getter)* (35 postings) and *research skills* (30 postings) (see Fig. 3.). No codes that indicate competency within a specific biomedical engineering industry context were applied this frequently in the ‘qualifications’ sections of the job postings.

### D. Other Interesting Patterns

Beyond the responsibilities and qualifications listed in the job postings; we also examined the education requirements listed in the postings. Alongside a BME major, other ‘qualifying majors’ listed in the job postings commonly included engineering majors like mechanical engineering, chemical engineering, and electrical engineering, among others. Less frequently, other science degrees were also listed in the job postings as ‘qualifying majors.’ These majors included biochemistry, biology, chemistry, and computer science, among others.

*Coding* and *CAD* experience was also a commonly listed qualification or requirement in job postings (17 job postings for *coding* and 11 for *CAD*). Interestingly, job postings frequently

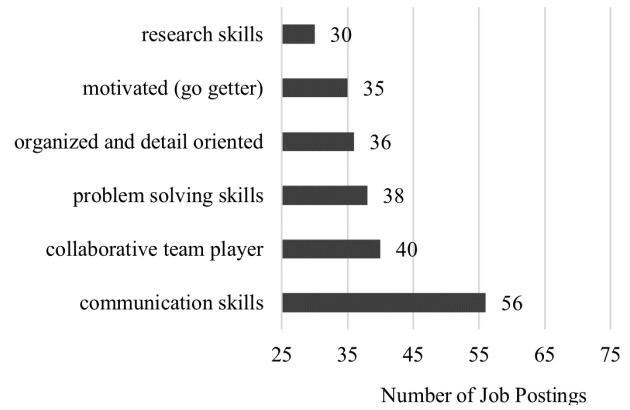


Fig. 3. Top job qualifications codes applied.

listed specific software systems that prospective employees should have experience in including general coding systems like MATLAB, Python, C/C++, R, and Others (listed from most frequently cited to least) and CAD software like SolidWorks (related – Creo and ProE) and AutoCAD.

## IV. DISCUSSION

The results of this analysis highlight the relative importance of BME students’ ability to communicate technical information. Over two-thirds of the job postings analyzed described some form of *technical documentation or communication* as a key job responsibility. This emphasis is important to note as universities create or modify BME curricula. Explicit instruction on technical communication may be a valuable addition to the core curriculum for BME students moving forward. Further, the job postings we found often described responsibilities in line with *quality*, *design and development*, and *manufacturing* roles. ‘Responsibilities’ codes also indicated the importance of being a good team member (*collaborative team player* and *cross-functionality skills* codes) in the job postings analyzed. While most BME graduates will have exposure to teamwork and some *design and development* practices through capstone design courses [9], programs often do not require coursework that teaches *quality* or *manufacturing* practices, leaving students to seek out experience in those areas of industry practice on their own.

Interestingly, and perhaps because many of the job postings in this analysis were specific to co-op or internship positions, the ‘qualifications’ sections most frequently listed broad professional or technical skills, rather than skills related to BME content (e.g., *medical device*, *biotechnology / pharmaceuticals*, *microfluidics*, *biomechanics*, *bioelectrical / biosensors*). It is possible that employers understand that candidates, especially at the entry-level, might not have previous training or experience in the industry. This could be a possible reason why broad professional skills are listed as desired qualification in job postings. Employer expectation of specific technical skills for BME graduates needs to be further explored in order to examine alignment between curriculum and industry needs.

Within the ‘qualifications’ codes in this analysis, research and problem-solving skills were among the top for technical skills desired of candidates. This finding provides support for

the importance of providing opportunities to problem solve and perform research within the BME curriculum. One way that this is currently being achieved in BME programs is through first-year and senior design projects [9]; however, earlier and/or more consistent opportunities for these experiences could be beneficial to BME students seeking industry positions upon graduation. Multiple professional skills and characteristics like motivation (*motivated (go getter)*), organization (*organized and detail oriented*), teamwork skills (*collaborative team player*), and *communication skills* were also among the top qualifications listed in the job postings analyzed, some of which align with previous work aimed at identifying the top skills for BME bachelor's degree graduates [8], [9]. While students have the opportunity to develop these throughout an undergraduate BME degree, they are often not explicitly taught. Additionally, within the realm of applying for jobs, it is unclear how these skills can or should be portrayed in application materials. Since professional skills are among the top sought after qualifications of prospective employees in our analysis, this observation warrants further investigation, which our future work aims to explore.

In general, we noticed that the formatting (i.e., order of information, bulleted versus paragraphs of lists, etc.), terminology for similar concepts (e.g., 'able to work on a team' versus 'a team player'), and information provided in the postings (i.e., company background, job responsibilities, educational requirements, and desired qualifications) varied tremendously across job postings, even within the same databases. Further, the job postings themselves were often times vague or unclear about their expectations and job duties for the position posted. This aligns with the idea that the BME industry is composed of multiple professional communities of practice with differing values and communication systems which makes identifying clusters of BME specific skills difficult. The breadth and ambiguity associated with the job postings we identified might allow for more candidates to consider applying for the jobs; however, more clear and targeted communication of job responsibilities and desired qualifications could benefit candidates as well as employers by allowing for alignment of candidates' skills with employers' desired skills or abilities. In order to help students make sense of and navigate the overarching BME landscape of practice, it is important to continue conversations about and research what professional practice looks like in BME.

## V. FUTURE WORK

To continue efforts to understand the BME landscape of practice, patterns identified in this study will be used to inform further research that explores how job postings align with the views of BME industry employers performing resume reviews. Understanding how employers' views align with the findings of this study can further our understanding and guide BME students toward more purposeful engagement in undergraduate experiences (class, co-curricular, or other) that help them develop competence that is relevant for industry careers.

The result of this work is currently being used to create archetypal resumes that represent a BME undergraduate student experience and highlight the themes observed in the job postings. Archetypal resumes will then be used as an artifact to

inform an interview protocol that employs think-aloud and semi-structured interview methods [12], which is a strategy similar to a study examining recruiter's perceptions of MBA students in interviews [13]. Industry representatives will be asked to provide a recently filled or open job posting for their company before participating in the interview. Based on the posting provided, subsets ( $n = 4$ ) of archetypal resumes will be selected to align with the descriptions in the job posting and structure the conversation. In the interview, industry representatives will be asked to briefly review the resumes and describe their review process (i.e., what section they are looking at, what they are looking for, reactions to content, etc.). After completing the initial think-aloud review, industry representatives will be asked to rank the resumes from most likely to least likely to offer an interview and then answer a series of semi-structured questions about their resume review process.

Interviews will be recorded and transcribed. An inductive approach to analysis will again be used to examine patterns in how industry employers describe their resume review process and what qualifications they connect to the experiences represented on the archetypal resumes. Comparisons across results from the job posting content analysis and the interview analysis will also be made to understand connections between how qualifications are represented in job postings and interpreted on resumes.

## VI. CONCLUSION

Results of this full project are anticipated to provide insights on what experiences and qualifications are advertised as important for BME jobs, examine the alignment between what is included in job postings and what hiring managers express as important when reviewing resumes, examine the alignment between industry and academic BME practices, and provide strategies BME students and educators can employ to improve students' ability to be hired upon graduation. By intentionally exploring what industry looks for in BME hires through multiple means of data collection, this work will add to BME educators' understanding of what skills, experiences, competencies BME students need to succeed in the job search process.

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