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Recommended Citation

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Abstract— **In this research category, work-in-progress study, the authors conducted eleven semi-structured interviews of employers (five from the United States and six from Sweden), in order to determine the information literacy skills and habits needed by engineering and technology graduates. The authors found similar information needs at both the Swedish and American corporations. They found that, while the core information literacy principles of identifying an information need, locating, accessing, evaluating, integrating, and documenting are valuable skills for students to have, they need to be translated to accommodate the socially constructed information landscapes of each corporation and the more fluid and subtle requirements of workplace information problems. Librarians and engineering educators need to construct more authentic information environments in their courses and design projects, so students will be better prepared to navigate corporate information spaces and culture.**

Keywords—information use, workforce education, lifelong learning, information literacy

I. INTRODUCTION

Information literacy (IL) has long been a part of undergraduate education in United States, Sweden and many other countries across the globe. Librarians together with instructors teach students how to identify, search for, and recognize high quality information sources relevant for assignments and projects. The need for, and usage of, information varies with academic discipline, and IL instruction is most effective when tailored to meet the specific learning objectives of courses and assignments [1]. A body of literature on IL instruction for engineering students has evolved during the past decade, which also points to the effectiveness of embedding IL instruction in engineering design courses that require students to solve a particular problem [1]-[2].

Although the purpose of IL instruction is to provide students with lifelong learning skills, the reality is that is has proven difficult for engineering students to transfer information literacy skills learned at the university to the workplace [3]. Lloyd [4], for example, has pointed out that librarians are too focused on teaching specific skills to meet academic objectives, that it makes the transfer to the workplace more difficult for students. She argues that the challenge for librarians is to align instruction with a complex and socially constructed workplace with unique information practices. Being information literate in the workplace requires the knowledge of a specific setting, which differs significantly from the skills-based IL instructions dominant in higher education.

Several recent studies [5]-[6] have explored this gap by comparing the difference in how practicing engineers use information in the workplace with that of engineering students and academic faculty. Phillips et al. [6] findings resonate with Lloyd's arguments that the information landscape in the workplace is far more complex, that the problems practicing engineers solve are often more ill-defined and access to information in the workplace is more unstructured and difficult to navigate compared to that in university libraries. Practicing engineers are also more likely to depend on informal information channels such as personal networks, technical literature, non-academic sources and standards. Kaufmann et al. [5] propose that, with increased knowledge of how practicing engineers access and use information in the workplace, it will be easier for librarians to tailor instruction that better matches real life problems.

To gain additional understanding of the potential disconnect between academic and actual knowledge acquisition practices in the workplace and the complexity of the information landscape that awaits new engineers, two sets of researchers conducted semi-structured interviews with eleven employers of engineering and engineering technology graduates in the United States (five employers) and Sweden (six employers). The research questions guiding this work are:

1) What expectations do employers who hire graduates of engineering and technology undergraduate programs have for new college hires, regarding their abilities to find and use information in the workplace?

2) From an employer perspective, what challenges relating to information use and solving information problems do engineering and technology graduates face in the workplace?

3) How can new graduates be better prepared for this new environment?

II. METHODS

This study is comparative, and the data was collected through semi-structured interviews. Before the data collection, compliance with the research-ethical regulations was assured through ethical clearance via the relevant bodies at both institutions, and informed consent forms aimed to safeguard the privacy of the participants and the legal and ethical integrity of the project. Both data collection and the data analysis were

supported by numerous online meetings involving both the Swedish and the American research groups. The meetings aimed to harmonize the collection and interpretation of the interview material across the two research groups and to discuss similarities and differences between the information landscapes emerging in the two countries [7].

A. Data Collection

The researchers conducted semi-structured interviews with employers based in their own countries. The length of each interview varied from 45 minutes to one hour. Two members of the team usually conducted interviews: one had the role of the interviewer, and the other was the 'recorder.' [8] We used a convenience sampling of the respondents: they were recruited among the authors' contacts of employers of their institution's students, but also involving relevant university bodies such as the Student and Education Office and the Alumni Office. The data collection took place between November 2019 and January 2020. All interviewees had the following characteristics: (a) they held managerial roles at large-sized companies, i.e., with at least 250 employees as determined by the OECD [9], and (b) had first-hand experience of hiring engineering and engineering technology graduates. Of the 11 interviewees, seven were male and four were female. Four of the interviewees had been on the job for 6-15 years, four for 16-25 years and three for 26 or more years. Each interview was fully transcribed and made available to both the American and the Swedish research group.

B. Data Analysis

The texts of the interviews were imported in the qualitative analysis software NVivo for thematic analysis [10]-[11]. Researcher bias was minimized by an independent identification of the themes within the two research groups and also between the authors' two research groups. The overarching approach of the thematic analysis [12] was abductive, including elements of deduction (pre-established themes) as well as induction (the emerging of themes from the data collected/created). To render a comprehensive description of the skills which employers would like newly-hired graduates to possess, we combined in one analytic framework two types of themes. The first were those predefined in our interview guide, explicitly elicited during the interviews, and derived by existing literature in workplace information literacy [13]-[14] and engineering information literacy [6]. Themes of the other type were the 'unexpected' ones, i.e., those which emerged from the interview data and the respondents' narratives. We used an iterative approach according to which we discussed the inclusion, exclusion and merging of themes, until an agreement between all authors was achieved. To date only a first pass of preliminary analysis has been conducted.

III. RESULTS

A preliminary analysis of the data reveals several major themes. While almost all themes appeared in both the Swedish and US based corporations, there was some variability in the frequency of the themes between countries. With a relatively small sample of five or six interviews from each country, it is too early to draw any conclusions about systematic differences between the two pools of data.

The most prominent themes include Gathering Information, Evaluation and Synthesis, Use of Specific Types of Information, Learning, Navigating Internal Systems, and Satisfaction with New Hires. Themes that appeared less frequently include Interpersonal Skills, Communicating and Documenting, Independence, Flexibility, Appropriately Framing the Problem, Knowing What Information is Good Enough, and Mentoring. Employers stressed the ill-defined nature of information gathering in the workplace, since 'real life' is more challenging, has specific requirements, and has more significant consequences (e.g., failure of a product) than an academic analysis. Specific comments could be coded with multiple themes, for example, the statement 'learn how to find internal guidelines' relates to both Gathering Information as well as Navigating Internal Systems. What follows are summaries of the most prominent themes from the interviews.

A. Gathering Information

Gathering information refers to the process of being able to locate appropriate information in an effective and timely manner. Comments related to gathering information referred to what information was needed (e.g., product information, customer information) as well as the process (finding it quickly, knowing when to stop searching). They describe challenges new hires face, such as not knowing how to 'move beyond the textbook' or test the information they find. One respondent described a Go, Look, See approach to finding information, stressing the need to actually visit the place where the problem is occurring, to understand what is going on at a deep level and what the opportunities are for innovating/problem solving. Information about the problem needs to be gathered, as well as solutions from the literature. Respondents also described the value of identifying person-based resources to help with information gathering and the need to cultivate experts in the organization. Interpersonal skills are key for new hires in order to manage those relationships and navigate the information, both tacit and explicit, available to the organization.

B. Evaluation and Synthesis

Respondents described the importance of new hires analyzing and evaluating the information they gather and, indeed, of the problem they are solving. They need to determine what information is important and appropriate for their research requirements, the ability to see different points of view, and the 'ability to see through information' to determine what is missing and what needs to be validated/confirmed. The new hires need to be able to frame the problem appropriately (i.e., not just what data is needed, but the larger context of the problem). As a result they need to know when they need 'high-fidelity' information and when what they have is 'good enough,' e.g., how mission critical the information need is, or

if it is just being used as a starting point for further investigation or testing. New hires need to be able to weigh arguments and 'debate' with others in order to figure out where holes might be that need further clarification or interpretation. Ultimately, to be responsive to the fast-paced demands of the corporate culture, they need to determine when their information search is over, so they can move on to their next task. In order to do that they need to synthesize information from multiple sources, identify gaps, differences of perspective, and resolve those issues. They need to keep the big picture in mind, i.e., what new information would make a difference, and not just gather information for completeness if it doesn't add to the understanding of the problem at hand.

C. Use of Specific Types of Information

Comments in this category include mentions of specific types of information (e.g., patents, standards, internal guidelines, safety, compliance, research articles, product information, properties, people, Mil Specs, YouTube, Wikipedia). Respondents' comments indicated that new hires apply new technologies well. They stressed that sources need to be appropriate for the information/learning need. There wasn't a particular mention of students having difficulty with specific types of information sources, although navigating internal documentation, which might not be well organized, seemed to a common challenge (described later). In general, new hires were seen as able to navigate internet resources well. Interactions with corporate libraries and, thus, to some of the more rigorous external sources of information, showed more variability among the organizations and even for different roles within an organization. The more Research and Development focused the position, the more likely they utilize 'library resources,' similar to what others have found [15]. Respondents supervising front-line, 'on the production floor,' positions focused more on internal documentation as primary, and new hires might only have mediated access to their corporate information center, through their supervisor, on a document by document basis.

D. Learning

New hires need to be prepared not only to find information and data to solve a specific problems, but they also need to be ready to pick up new skills (including 'soft skills' such as communication and social skills), learn programming languages, and otherwise use information for their own professional development and learning program. Much learning happens independently, and the expectation is that students should be independent learners. Some companies offer centralized educational resources/training that new hires can avail themselves of, particularly on how to use internal systems and procedures, while one is looking into VR training so new hires can simulate a work environment. One corporation described an online learning management system, so the company and individual can track their training history. One employer provided the perspective that the 'degree isn't the last step, but the first step...you're a freshman again in the new company.' Many new hires come in after their course of study, believing they know everything they need in order to succeed. Rather respondents indicated the degree typically only provides the foundations and context for their workplace experiences. Again, some new hires in more frontline roles may need to work through their supervisors to get approval for training, or the supervisor might be responsible for determining and acquiring training for the new hire.

E. Navigating Internal Systems

Navigating the internal knowledge management system of an organization is seen as one of the most important needs for new hires. Frequently, these internal materials are embedded in homegrown databases or systems that have evolved over many years or even decades and contain legacy software, interfaces, and structures. Materials might even not be digitized, so looking through print repositories is required. Often, there is dissatisfaction with ease of use of these systems, but they are important and, frequently, required responsibilities for new hires not just to extract information from the system, but to populate the system with content as well. For some industries, compliance or communication across multi-disciplinary or multi-unit project teams requires employees accurately and consistently log their activities and decision-making. New hires might need to create their own technical reports investigating a problem for the organization, internal process documents, and even write internal standards for the organization. Internal knowledge management systems may also limit access to certain information by role or work area, so it is possible that the information is available, but just not to the individual...in that case, finding someone with access/awareness is also important.

F. Satisfaction with New Hires

It should be noted that, overall, the respondents expressed satisfaction with their new hires. They felt that most could meet the challenges of the workplace. They recognize that new hires do have their challenges, transitioning to the workplace and learning new systems and processes, but the employers felt that new hires come with skills in locating information, and particularly, in presenting and communicating information. One employer noted that 'new hires challenge the status quo... help experienced staff re-examine their assumptions, see if anything has changed so a solution is now possible that wasn't before.' Many of the employers hire students who they have pre-existing relationships with, for example, who have done sponsored capstone design projects with the organization, so they have, in a sense, pre-screened their new hires and pick the ones who have the skills they are looking for. Employers in both countries described having mentoring programs or extensive onboarding programs in place for new hires. Matching new hires with more experienced employees, or managers, allows for acculturation into the new

organization, including how to navigate its information landscape.

IV. DISCUSSION

Conceptualizing the workplace information process as a socio-cultural exercise provides a framework for making meaning and tying together the results of this study. According to Lloyd [16, p.10], each organization has an information landscape that is a space created by the human interactions in which information is created and shared, and "to become an insider requires access to information that is valued and sanctioned within that space, allowing interrogations, interpretation and mapping of information. This requires knowing about the sources of information that will inform practice, why they are valued and sanctioned by the community, how they are nuanced and the ways in which they can be accessed."

While the respondents described many similar information needs and skills required across the different corporations, they did focus on the unique environment of their own workplace. In that sense, Lloyd's approach of considering the information landscape at the organizational level, is a useful way to frame the results of the interviews. The exact internal knowledge management processes are unique to the corporation itself, the type of corporation it is and potential compliance and regulatory requirements inherent in its work. Each respondent described a variety of ways in which new hires interact in the information environment of their organization. They need to learn these systems, navigate the people-knowledge centers of the organization, and determine the best way to organize and communicate their findings in the socio-cultural workplace environment.

It is not a novel finding that engineers tend to consult colleagues before turning to more formal sources of information (i.e., traditional 'library' resources). While prior literature might have attributed this to a least effort approach to finding information, in our interviews it became apparent that beyond just being the fastest way of potentially finding information, a colleague also provides a cultural context for the problem. It is not just about finding a factual answer, but the answer that aligns with the corporate culture and permissible courses of action. While one respondent cautioned against new hires accepting the 'we tried that once and it didn't work' dismissal of a potential solution, they do need to understand why that approach didn't work in the past and how the environment or technology might have changed to enable its success currently.

V. CONCLUSION

Based on the results of these interviews, it is apparent that librarians and engineering educators need to construct more authentic information environments in coursework, so that students are better prepared to navigate in the corporate environments they will be working in. Rather than just focusing on 'the library' or just 'finding the person down the hall who knows how to do that,' an integrated model of information literacy will ask students to interrogate the strengths and weaknesses of both formal and informal information sources to find the optimal ones in the context of their own (and their supervisor/mentor's) information need. It will treat students as contributors to, and not just consumers of, information, situating students as equal members of a community of inquiry. For example, requiring not just final papers or presentations, but 'hand-off' documents that summarize the technical information a group would need to pick up or move forward the project, would more closely replicate the workplace environment, where a project typically is not completed from beginning to end by a single work team. Only by creating these authentic spaces, can educators feel that they have prepared students to optimally acquire and apply new knowledge and be successful in our increasingly information-based workplace.

VI. LIMITATIONS AND FUTURE WORK

This was a pilot project to uncover major themes identified by employers of engineering and technology graduates of the researchers' institutions. Although we interviewed supervisors who had a variety of roles within the organiziations, our results are necessarily a small, convenience sample, and, thus, the results are not generalizable to industry at large. The researchers will be expanding the sample size through further interviews of employers as well as surveys of students and employers, in order to obtain more generalizable findings.

VII. APPENDIX

Interview Questions:

1. What are typical entry level positions you hire graduates of engineering and engineering technology undergraduate programs into?
2. Can you give some examples of the kinds of problems these new university hires need to solve on the job?
3. What expectations do you have for their abilities to locate, use, and manage information in the workplace?
3a. What types of information do they need to know how to use?
3b. What do they use the information for?
3c. How well do they apply information appropriately?
3d. How well do they find high-quality information to answer their needs?
4. What typical struggles do they have in locating, using, and managing information?
5. What do new hires typically do well when it comes to locating, using, and managing information?
6. How can students be better prepared for the work environment when it comes to their information skills?
6a. Can you think of any particular assignments or projects that could be integrated or modified during a student's academic career that would better prepare them for the information needs of the workplace?
7. What on the job training do they receive with regard to navigating/using information?
8. Does your organization have a library or technical information center? If so, can you briefly describe its constitution and the services it provides?

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