

Situated Information Seeking for Learning: A Case Study of Workplace Cognition among Cybersecurity Professionals

Abstract

Workforce development in engineering is a high priority to keep pace with innovation and change within engineering disciplines and also within organizations. Increasingly, workforce development requires more retraining and retooling of employees than ever before as information technology has accelerated both the creation of a new body of knowledge and also the skills required to perform the work. In this paper we present a field study of a highly dynamic workplace – a cybersecurity firm – undertaken to better understand how engineers keep up with the pace of knowledge that is needed for their work. Fifteen professionals, with a wide range of experience and educational background, were interviewed. Data were analyzed iteratively and interpretively. The findings from the study suggest that over time some well-defined ways of learning had developed in the workplace we studied. These learning practices combined in-person and online interactions and resources. We also found that learning was triggered largely by the need to solve a problem or by the interests of the engineers to learn more in order to be prepared for new knowledge in the field. Depending on the problem they faced, the engineers mapped the requirements of what was needed to solve the problem, identified the resources that were available, and then selected the optimal resource. Often, as is common with problem solving, our participants had to try out multiple options. Theoretically, our study contributes by integrating an information seeking perspective with situated cognition to inform future studies of learning in information rich engineering and technology workplaces.

Keywords: Situated Learning; Information Seeking; Cybersecurity

Introduction

Professional engineering workplaces serve as a core site for engineering learning and the role of workplace learning is starting to become well documented in the engineering education literature. The practices of workplace learning though are shifting substantially with recent developments in information technology (IT) and these changes have made the professional engineering workplace an intriguing site to learn more about engineering learning from both a practical, normative, perspective but also, as scholars are starting to argue, from a theoretical viewpoint. The changes that are occurring in the engineering workplace from the perspective of learning are multi-pronged. First, as the work of engineers has changed, and continues to change, so does the knowledge that is required to perform that work. This necessitates continuous learning to keep up with a changing body of knowledge. Second, with the change in the body of knowledge, there are also changes in how that knowledge can be acquired. In other words, technology changes not just the work but also how one learns about how to do that work. Third, and most critically, the fusion of changing knowledge and ways in which that knowledge can be acquired is giving rise to new practices of learning that are novel because they are both reified and malleable – they exist but are also continuously changing. More than any other aspect of workplace learning it is these shifting practices that make engineering learning the most challenging; their dynamicity and unpredictability is something for which advance preparation is often inadequate and for which future preparation fails as what one is prepared for is often not what the future brings. In other words, the present is situated.

In this paper we present an empirical study that highlights these challenges and also documents how engineers in the workplace address the challenges they face. We then use our data not just to discuss practical issues of interest but to develop theory that can help guide future research and practice. Our empirical case study comes from the domain of cybersecurity, an interdisciplinary area that attracts engineers from across a range of disciplines. Cybersecurity work changes continuously and the knowledge required to address workplace challenges is also learned in both traditional and novel ways. To frame our work theoretically we leverage a situated learning perspective in conjunction with an information seeking perspective. Although the situated learning perspective is well documented in engineering education literature, the information seeking perspective is less so. We use them both, as we discuss later, because they provide us an empirical starting point to examine learning in information technology (IT) infused workplace. For our theory development we draw on a situated learning perspective [10, 11, 17] but enhance it by integrating a genre perspective to argue for a novel lens that allows a better focal point to understand physical-virtual integrated learning environments, of which the engineering workplace is a prime example [22].

Situated Information Seeking Perspective on Workplace Learning

Situativity refers to the influence of context in what people say about others and how they talk about it. The situative perspective views knowledge “as distributed among people and their environments, including objects, artifacts, tools, books, and the communities of which they are a part” [6; p. 17] and learning is conceptualized as meaningful participation in a community of practice. There is an understanding that “the constraints and affordances of social practices and of the material and technological systems of environments” [6; p. 17] shape learning significantly. The situative movement differs significantly from prior approaches such as the behaviorist and cognitive perspectives in its emphasis on the role of the environment on an individual’s conception of knowing and how they learn – knowledge is not something that an individual possesses or stores in the brain but is present in all that they do. The situative perspective emphasizes that in cognition what and how are closely linked. This situation, or context, determines what people look for, how they get the information, and how they interpret the information. The situative perspective views human knowledge as arising dynamically, as being constructed and/or reinterpreted, within a specific social context [2]. Furthermore, knowledge is socially reproduced and learning occurs through participation in meaningful activities that are part of a community of practice [17]. Although previous work on situated cognition and situated activity has focused specifically on tasks and learning within organizational settings [17, 25] recent work [5] suggests that it can provide as with an appropriate lens to look at other elements of organizational cognition as well. This perspective emphasizes that the context, tools, and relationships people have significantly affect how they learn and what they learn. The situated cognition approach is uniquely suited for a study on workplace practices as learning to participate is a cognitive process, it entails learning about others, and it occurs in specific context. According to Billett [1], to conceptualize workplaces as legitimate learning environments it is necessary to transform the current discourse and move beyond articulating learning through work as being informal, non-formal or unstructured learning as these descriptions hinder a better understanding of workplaces as learning spaces [13, 16].

To understand the process of learning in information rich workplace contexts we also approached the problem from the perspective of information seeking for learning. There were both theoretical and practical reasons for focusing on the information needs of professionals as a way to understand learning. We wanted to examine learning in-situ, as it was triggered in the workplace, and invariably information seeking was a precursor to that process. Professional training and similar efforts are important but we wanted to understand their role within work practices and not just as certification or requirements. Theoretically, there is significant work in the Information Sciences pointing to the role of information seeking in the learning process. This literature although pertinent is often overlooked when learning is examined within more established and formal setting. We also wanted to take an information seeking perspective given the significant role that technology, especially the Internet and search, plays in the learning process now. Scholars are increasingly pointing to information seeking as a way to examine learning because in many situations learning begins with information seeking – it is motivated by the need to know something and before something can be known, it has to be acknowledged. The information seeking process does precisely this – it explicitly makes something unknown into knowable.

Studies of information seeking shed some interesting light on how different professionals look for information. Davies [4] reviewed literature on information seeking among doctors and found that converting questions to a searchable phrase can be a challenge for inexperienced searchers. In terms of the type of resources that are used, textbooks were used 39% of the time, followed by ‘humans’ at 25%, and computers were used on average at 13%. Hemminger et al. [7] looked at the information seeking behaviors of academic scientists and found that personal communication was the most popular source for non-scholarly information, and that there has been a tremendous shift in the way information is accessed compared to before. There have also been studies that have tried to characterize the information seeking process [15, 18, 24] and most accounts describe a process of an interaction cycle that consist of identifying the information need, activities that query for the information, examination of the results, and if needed, a reformulation of the query. This process repeats itself until the user is satisfied with the results. This framework is applicable to problem solving. Within cybersecurity, Rader & Wash [19] looked at the top 10 topics that users are reading in order to learn about new security trends and topics and found that most users get their knowledge about security from stories, news articles, and web pages with security advice. When looking specifically at non-experts, Rader, Wash, & Brooks [20] found that non-experts in security learn their lessons from informal stories from friends and families. These stories impact the way they think and response to situations that they see while online. Finally, in a study of security experts [8] examined experts’ decision making during security assessments and found that experts differ from novices on how they recognize certain attack models. In our work we wanted to further understand similar practices and therefore opted to look at a domain where work is in constant flux thereby requiring new expertise. We also wanted to look at a domain where the change in knowledge is fast. Consequently, we picked cybersecurity professionals as the target group. We now discuss this domain further.

Research Context and Study

Cybersecurity Domain as Context for Study

The cybersecurity domain is vast and ever changing. From networking, hardware, software, privacy, usability – a varied nature of expertise and work is encompassed by the domain. The knowledge required and the area of expertise also keeps changing. For instance, in the last decade security of mobile devices has emerged as a critical domain. Even more recently, cloud computing has brought about one another big shift whereby rather than a focus on standalone devices such as desktops, the focus of security is on data warehouses and the transfer of data across devices and platforms. Although some core knowledge is relevant as these changes occur, there is also substantial demand to acquire new knowledge.

Currently, a large number of formal degree programs prepare students for the cybersecurity workforce. Some of these programs are specific to cybersecurity and some of them are traditional engineering programs that have an emphasis – either through a minor or a certificate – on cybersecurity. In addition to college degrees professional development within cybersecurity is also strongly driven by external certification courses and agencies such as CompTIA™. These programs have found niche in training professionals precisely because the field is so dynamic and for professionals to keep up it is necessary to learn new things. Even then, formal programs are limited in how much training they can provide and on the job learning is critical for success in the cybersecurity profession. Cybersecurity is also challenging professionally because even though a professional might be well trained in a specific subdomain, solution to a problem might require the integration of knowledge in multiple domains. This is challenging as most professionals do not have all the knowledge in every domain and have to rely on external sources to accomplish their tasks.

The following research questions motivated our study:

- 1) How do cybersecurity professionals seek usable information during their work?
- 2) What specific information do cybersecurity professionals seek?

Research Methods, Data Collection and Analysis

Given the open ended nature of the research questions and a general lack of research that used an information seeking perspective to examine learning, a qualitative interview study was deemed suitable for this research [3]. Interviews were conducted with 15 cybersecurity professionals. The interviews were conducted within a period of one month at local café. Given the highly secure nature of many cybersecurity firms and limitations of access, conducting the interviews in the firms' premises was not deemed suitable. To ensure that the location was convenient to participants, a local café was chosen that made interviewing conducive. The interview participants had a wide range of experience and educational background. Some were newer to the field, with five to ten years' experience, while some had over 15 years of experience. Cybersecurity is a field that often hires people based on their experience, rather than their educational background. This is represented in the study by the fact that about half of the participants did not have a college degree, although some are in the process of working towards it. The participants in this study averages about 10-15 years of experience, with a mixture of education background including high school all the way to Master's degrees.

Each interview lasted approximately 45 minutes to 1 hour and was recorded using an audio recorder. The interviews were conducted in an open format, with questions designed to be open ended in order to encourage the interviewee to be able to discuss topics that are relevant or important to them. Keeping it open ended allowed the author to gather information that was not accounted for in the interview protocol. It also allowed the author to have more of a conversation with the professional, rather than a full question and answer format. The recordings were transcribed into text and analysis was done using standard coding and interpretive methods. Through this process, a theory was developed based on what was learned. Open coding of the text was performed to divide the data into similar groupings and developed categories about the phenomenon that was observed [14, 23].

Table 1 - Interview study participants

Participant	Years of Experience	Education	Background
P1	20+	BS	Security, developer, business integration
P2	15+	MS	IT, Security, System Administration, Networking
P3	10+	BS	Cloud security, networking
P4	5+	High School	System administration, security tools
P5	5+	High School	Penetration testing, insider threat
P6	20+	BS	Security, IT, Tools
P7	15+	High School	Banking, Business, IT
P8	10+	BS	IT, System Administration, Security
P9	20+	High School	Encryption, Pre-Sales, Support engineer
P10	25+	BS	Project Manager
P11	15+	BS	Security policy and management
P12	10	BS	System administrator, Help Desk
P13	15	MS	Network administrator
P14	15	BS	Vendor security, contracts
P15	10	High School	Security policy, exceptions

Findings

A Process Driven Explanation of Information Seeking and Learning

Through the interviews one of the first things that was reiterated by the participants was a process based approach of seeking information in an effort to learn. Overall, depending on the problem they faced, professionals first mapped the requirements of what was needed to solve the problem, identified the resources that were to them available, and selected the optimal resource. This process was repeated iteratively until the need for information and learning was fulfilled. Based on the response received from the participants, we developed a framework that depicts the main elements of this information seeking process that is targeted towards learning. We outline this process, for analytical purposes, in Figure 1. Next, we discuss each stage of the process and in Figure 2 we further clarify some of the sub-elements of each stage of the process. This framework served as an interpretive device for our analysis and also directed our focus towards resource utilization (which we discuss in the next section).

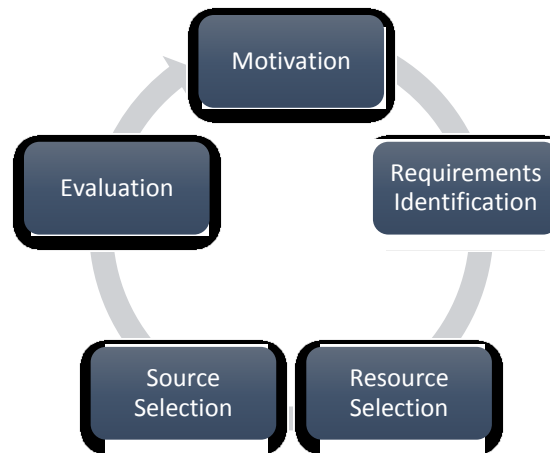


Figure 1 – Process of seeking information for learning

Stage 1 - Motivation

The first stage in the process is motivation for seeking information and in our study we identified two reasons that motivated this – problem solving and interest. Problem solving was the most common trigger for information seeking towards learning and invariably participants reported running into a problem with their work and then looking for information to help them resolve the issue. This information was invariably new information that was needed and therefore they had to learn something to solve their problem. The second trigger was an interest in a topic often because it was a new topic that they perceived as being relevant to their profession, either currently or in the near future. To fulfill this need they often took continuing education classes or industry certifications but also undertook self-learning. Time spent learning motivated by problem solving was typically short term in nature, whereas learning that is motivated by interest was longer.

Stage 2 – Requirements Identification

Participants reported that once they were motivated, they identified what information was needed to help solve the problem. There are a number of factors that were identified based on the findings from the interviews. The factors determine the type of resource that will be utilized in the next stage of the framework. There are two types of resources that professionals would use for learning and knowledge acquisition, Human and Online. Human resources are defined as information sources that come directly from the interaction with colleagues and other people. Not to be confused with human resource departments that are found within most organizations. Online resources are sources that come from accessing the internet through the use of a browser or mobile devices. The types of resources will be explained in detail in the following sections.

Stage 3 – Resource Selection

In this stage, the professional determine the type of resource that will be used to learn and acquire information. The choice of the resource is driven by the factors in the previous stage. There are two main categories of resources, human and online resources. This stage only highlight the initial type of resource that is being used, and depending on whether or not the information need is met, the professional will go back to this stage and select another resource

appropriately until they acquire the information that is needed. Each type of resource identified here served as the starting point for the search process.

Stage 4 – Source Selection

Selection is the final process in which the professional select the actual source of information that is presented from the resource they have chosen. The selection of the source is driven by factors that have been identified from interviews. When the professional search for what they need from a specific resource, there will be multiple options that will be presented to them, so these factors are what guide them to each specific source from the resource they originally chose. There are multiple factors that go into the selection process, these factors are things the professional look for in order to make their decision on which source will meet their information need.

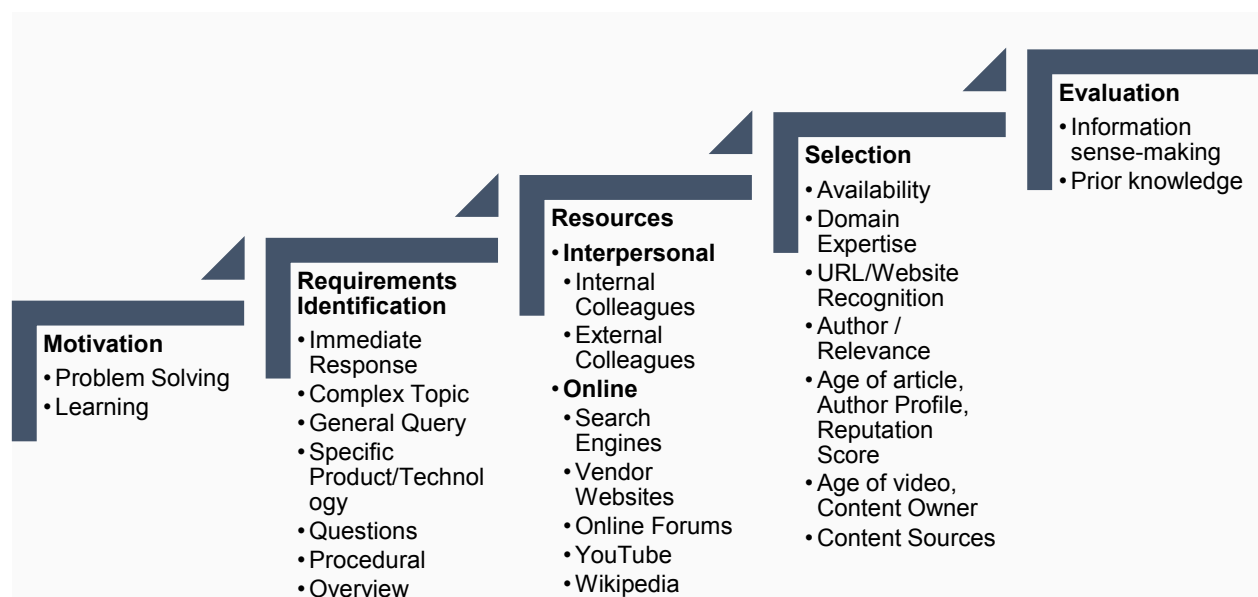


Figure 2- Information seeking process flow

Stage 5 – Evaluation

In this final stage, the professional evaluate the information they have learned throughout this process, and determine if their information need has been fulfilled. If the information need is not fulfilled, then the professional would go through the process again and either utilized a different resource, or select a different source from what was available before.

For each professional, their method of evaluating what they have learned varied based on their previous experience. Professionals with more experience found it easier to make this determination whereas newcomers required additional steps to verify the information. About half of our interviewees reported that they verified the information they learned by using another resource. The information seeking process cycle repeated itself until the professional had fulfilled their information need. In each of the five stages, there were additional corresponding factors that contributed to the selection of the resources. These factors are outlined under each stage in Figure 2.

Resource Utilization

The second research question addressed how professionals view the different type of resources available to them, how they use them, the advantages and disadvantages of each type, as well as factors that influence their decision in choosing the type of resource when seeking information. Table 2 summarizes the more frequently used resources that were identified.

Table 2 - Summary of resources utilized, perceived advantages, and disadvantages

Resources	Description	Advantages	Disadvantages
Interpersonal			
<i>Internal Colleagues</i>	Colleagues from same working group	Immediate response Prior experience in similar projects	Lack of availability Knowledge bias
<i>External Colleagues</i>	Colleagues from different teams or organizations Vendor representatives	External knowledge Domain expertise	Lack of availability Non-disclosure agreements
Online			
<i>Search Engines</i>	Google, Bing	Good starting point when there is limited knowledge of topic Covers all topic areas	Requires specific query to narrow down to specific results Must filter through large amount of information
<i>Vendor Resources</i>	Sites and resources maintained by vendors (Microsoft, Cisco, etc)	Trustworthy for specific application/technology	Limited to specific product or technology Does not provide solutions to situation involving multiple technologies or products Product bias by vendor
<i>Online Forums</i>	Discussion and Q&A forums (StackExchange, etc)	Provide solutions to common problems Provide answers to very specific scenarios	Trustworthiness of information is questionable depending on forum used
<i>Video Sharing Service</i>	Platform to view videos (YouTube)	Effective for instructional and procedural types of information Preferred learning format for most professionals	Requires longer time investment than text sources
<i>Whitepapers</i>	Technical documents written by security experts	Effective for highly technical information or topics	Content typically requires domain knowledge to comprehend
<i>Online repositories</i>	Wikipedia	Commonly used for high level summary Extensive number of articles available	Content trust is mixed Requires additional source of information to verify information provided

Interpersonal resources are often used first

There are two main types of resources that are available to the professionals, interpersonal, other people they know, or online repositories. Within interpersonal resource, two types of colleagues were drawn upon – internal to the organization and external to the organization. Internal colleagues are those who work in the same team or group as the professional. These are individuals who can be easily accessed when the need arises. Often these are teammates or co-workers who may reside in the same office. External colleagues are individuals who may be in a different group or may work outside of the company. For most professionals, internal colleagues are the first source they come to when seeking information. These individuals are the people that the professional will contact first, as they work in the same group and will typically have a better understanding of situation. When asked why colleagues are a good source of information, professionals explained that colleagues often have knowledge that they do not possess. Asking a colleague a question is often much faster than trying to search for the answer online, as the colleague will typically understand the problem and the context immediately. This has the advantage over trying to craft a query to search and then having to read through the large number of responses just to see if it matches with what is being asked.

In scenarios where the information required is more complex or require prior experience, the professional will typically use human resources as the starting point.

(P6) *“When I have questions regarding the tools that I manage, I often go to my colleague who already has previous experience in managing that tool. They already understand how it works and the issues often associated with it, so it is just easier to ask them directly for their input.”*

Professionals identified the three main advantages of using human resources:

1. Comprehension of complex scenarios or issues
2. Previous experience to similar situations
3. Faster response time when available

One professional explained their reason for always going to a colleague first when they have a question, quoting:

(P4) *“I always go to my colleague first because a lot of problems or issues that come have occurred before, so they may have knowledge to quickly solve the problem”*

When internal colleagues do not have knowledge about the domain area, the professionals have the option of contacting external colleagues for their information need. External colleagues may have knowledge that internal colleagues do not possess. This is due to the different nature of the work the external colleague may have, or because they are external to the team, they may have different views or opinions on specific issues. This can be helpful when the professional is seeking information that is outside the scope of their work, or when the information they seek is something that they could not obtain internally.

The professionals interviewed do not identify external colleagues as a frequent resource they use. First, as these individuals reside outside of the group, they may not have the same background knowledge as the professional. They might need more time in order to explain the situation and the specific information need. External colleagues who work at another company than the professional will also be limited in what information can be presented to them due to

confidentially issues. Companies typically do not allow their employees to provide details that might be sensitive to non-employees outside the company. Depending on the information that is required, the use of external colleagues might be limited due to confidentiality agreements that the professional has to adhere to. When a question arises regarding a product or situation that has occurred in the past, the professional will typically go to a colleague that has experienced it previously.

(P4) "When we have a problem with one of the tool I manage, I will usually go ask one of the guys who managed it before me to see if they have any input."

Sometimes, when a professional needed immediate response to their question, the internal colleague is also a great first source of information as the response will be immediate. This doesn't always guarantee that there will be a correct answer, but it serves well as the first source of information.

Limitations of human resources

Going to colleagues for information does have its disadvantages. First, the colleague might be busy at the moment the information is needed, so there is a wait time for when they become available. In a fast-paced work environment, this could mean waiting for hours if the person is busy in meetings or other matters. In a time sensitive scenario, this might not be the best source of information. In most case, if the professional discover that their colleagues are not immediately available, they will utilize online resource to find the information they need while they wait for the colleague to be available. If they are able to find the information they need, then they will no longer need the additional human resource. Colleagues are a good source of information but the reliant on them will be determined by their availability. The lack of availability is one of the main disadvantages of using human resources. This lack of availability often means the professional will seek information online, where it is always available at any time.

There are limitations to what colleagues can help assist. Typically, colleagues can provide their input and opinion on a topic area that they are familiar with. This requires the professional to know the background of the person they are asking. In a work environment, the professional will selectively choose the colleagues they ask based on the background of that person. This is often someone who is in the same team as the professional as they would be more likely to be doing similar work and can leverage the experience of the other person. Colleagues that work on different teams are only effective when the question at hand is in the domain of that person.

Online resources

Online resources are sources of information that can be found by accessing the internet. As there are countless numbers of websites out there, this paper will categorize the different types of resources that are commonly used by professionals from the interviews. Five types of resources are identified through the interviews: search engines, vendor websites, online forums, YouTube, and online encyclopedia. Professionals use different types of resources depending on the information they are seeking.

Information trust

Although there are overlaps in the type of resources that are preferred by professionals, the level of trust for each of the resource is surprisingly different depending on who you ask. For example, online forums have been mentioned as a resource that is used, however, the level of trust that is given to forums is completely different. Some believe that online forums are a trustworthy resource, while others believe that forums only contains opinions and should only be taken with a grain of salt. One reason for this could be based on the type of forum that is being used. With many different forums out there, each professional are only familiar with the ones they use or know. The Stack Exchange forums has been identified as trustworthy and serve as a good source of information, whereas discussion forums from other communities do not have the same level of trust. Professionals that aren't familiar with Stack Exchange and other popular Q&A forums tend to have a negative view on forums as a whole. While those that have used Stack Exchange forums have found them to be trustworthy.

Websites that are hosted by the vendor or owner of the product are highly trusted.

(P1) "I generally use the vendor sites the most, Microsoft, Redhat, and others. I also use like ISC2 and CIS, I find those trustworthy because they are used by many businesses. I tend to stick to security sites or well known sites."

(P1) "I use online forums. Again those give me usually leads, what to look for, they don't always give me the answer what I need. They give you ideas of where else to look."

"Wikipedia, I take it with a grain of salt. It usually gives me idea of what else to look."

Use of search engines

Search engines are often the first go to place for professionals when they seek for information. This is where they will start their search by building queries and putting it into the search engine. Search engines used by professionals include Google, Bing, Yahoo, among others. Google is the de facto default engine that professionals go to, and almost all searches start out on it. Depending on the situation, the information required, and the availability of the resource, the professional will choose one resource as the starting point. When the information required is simple and has a straightforward answer, the professional will often use online resources to fulfill their information need as it is quicker.

(P1) "When I want to look up some information about a specific product, I just open up Google and do a quick search to read up on the information that is available."

Use of online resources provided by vendors

Vendor resources are websites that are hosted by the vendor themselves. They include product webpages, online forums, knowledge base, and other documentation that is specific to the vendor. These resources are typically more specific to a particular technology or product. For example, Microsoft hosts a knowledge base and online forum that is geared towards troubleshooting their products. Almost all of the professionals interviewed have used resources from the vendor and found them to be trustworthy. As many professionals work in an environment that use a specific type of security product, going directly to the vendor for help saves time as the content presented is tailored towards the specific product. Some professionals even identified this as the first resource they use when problems arise. One issue identified with vendor resources, is that they can be biased in the information that is provided. Vendors will

typically provide recommendations or suggest solutions that are geared towards their products. One professional stated, *“When using information resources from a vendor, you have to be careful as the information is biased towards their products. There could be better solutions out there for the issue you are having, but these resources will focus more on their own product or solution, which may not be the best.”*

This bias could prevent vendor-neutral information from being presented sufficiently. What is best for the organization might not be what is recommended from the vendor. This is important to keep in mind as professionals look at potential solutions to their problems. The information provided on these websites is from the vendor, along with other users who are knowledgeable about the product. On many vendor forums, there are representative and technical support personnel from the vendor that acts as moderator to the posts and questions from users. These representatives are a trustworthy resource as their credentials are clearly displayed within the forum. Vendors typically provide many avenue of information in order to assist their users. They can range from knowledge base to forums, to direct assistance with a representative. Information from these sources can come from representatives of the vendor themselves, to other users who are sharing information that they know. Knowledge base articles are typically written by the vendor themselves on common topic of interest, questions, or problems. These are trustworthy as the information is organized and is typically tested before releasing to the public. Large vendors often set up online forums on their webpages for users to be able to go in and post whenever they have questions or problems. These forums are monitored by representatives of the organization.

Wikipedia trustworthiness is mixed

Wikipedia has been a source of information that has a wide range of opinion on how trustworthy it is. Google will typically place search results from Wikipedia on the top of their search results, indicating that articles from Wikipedia are a trustworthy source of information. Our respondents reported a mixed preference for Wikipedia. For some, Wikipedia serves as a reliable source of information. One security manager says that he often refers to Wikipedia for “highly technical information”. While another professional uses Wikipedia, but he always take it “with a grain of salt” the information that is provided. What could be the reason why there is a gap in how different professional feel about it? One reason that could explain is the age difference. Wikipedia at its inception has always had a reputation of being an “untrustworthy” encyclopedia due to the way articles are written. The fact that anyone could modify the content of the articles has made it a resource that cannot fully be trusted nor cited in scholarly articles. In schools, students were usually told not to cite Wikipedia sources, and that perception still continues to this day. On the contrary, people have often used Wikipedia when looking for information, hence explaining why Google often places Wikipedia articles on the top of their search results.

Over the years, Wikipedia has slowly increased its reputation by maintaining the quality of their articles. This has improved people’s overall perception of their articles. Through interviews, the author has found that older professionals are more likely to not trust Wikipedia as a source of information, whereas the younger professionals tend to view it more positively. From the author’s point of view, Wikipedia does contain a high number of articles, often with citations to back up the information that is provided. And as a professional, the author does rely and trust the content of Wikipedia articles. Wikipedia often contains a summary of the information about a specific topic. As it typically appears as the first few links when searching on Google, it is often

used as a quick reference in order to quickly understand what the topic is about. On the page, Wikipedia will often provide links to other related topics. These hyperlinks allow Wikipedia to be used as a tool to explore other related topics. This is helpful for professionals who are trying to understand a new topic area by allowing them to quickly see related topic of interest.

YouTube is widely used for learning of procedural information

One source of information that was brought up as being commonly used is YouTube. In many companies, the use of YouTube is often frowned upon, and some companies even outright block YouTube from being accessed on their network. Almost all of the interview subjects mentioned YouTube as one of their go to source for information. One professional described YouTube as being a good source for “procedural or step-by-step instructions”. When it comes to needing specific step by step instructions, YouTube is a good source as it is often easier to follow. However, there are limitations as instructional videos on YouTube are often limited to general training, rather than specific for work environments.

YouTube was identified as one of the main avenue for learning. Many IT training courses can be found on the site, and are easily accessible as the content are free to all users. Professionals like the fact that videos are often easier to follow and learn from than reading articles. They preferred to watch videos over reading long articles. This is especially important for learning, as many professionals prefer to watch videos and learn rather than reading books or articles. Although most professionals like to use YouTube, one was skeptical of using YouTube video for learning purposes, with the reason being that they did not know who the individual is that created the video. This brought up an important point, as YouTube currently does not provide a way to prove the poster’s credentials or experience. Users rely on the number of views and “thumbs up” votes in order to determine if the video is trustworthy or worth watching. It would be beneficial if YouTube allowed companies or credentialed experts to be able to display a badge or some sort of identification in order to prove their trustworthiness to users.

Online forums are only used by some professionals

The use of online forums by professionals has been mixed based on the information learned from the interviews. There are three types of forums that have been identified as being commonly used by professionals; questions and answers, vendor forums, and hacking discussion forums. Different professionals have different type of exposure to each type of forum, some are familiar with all types, while others are only familiar with one or two forums that they commonly use. Each professional tend to stick to the type of forum that they are familiar and trust. A few professional regularly use Q&A forums such as StackExchange and ExpertsExchange. These professionals trust these forums due to the reputation system that allows users to rate the questions and answers. Key factors that are used when determining how trustworthy the information provided is based on the reputation score of the poster, the number of up votes the post has, and whether the answer has been marked as “Best Answer”.

Professionals that utilize StackExchange do not know or understand all the features that are available to them on the page. For example, they are not aware that on the right side of the page there is a list of similar questions or posts that they can look at when viewing a specific question. Most professionals that utilize forums only read the specific topic they are interested in and do not browse to other similar topics after they are done. Only one professional said that they

frequently browse other topics on the forums after they finished reading the post they were interested in. Professionals do not regularly post on the forums but instead only search through existing posts through search engines or using the “search” feature of the forum. This is due to the fact that the information they need is typically time sensitive, they need the information right away in order to do their job. Posting on a forum would mean that they would have to wait for someone to answer their question, which could take hours or days depending on the topic and the forum that is being used. Most professionals will typically search on a search engine, and get to the forum when its pages appear within the search results. This means that search engine must be able to index online forums in order for those pages to appear in the results. One professional stated that they post on the forums only as a last resort.

(P1) “I usually never post on a forum, the only time I post is when I have looked everywhere else and still cannot find the answer.”

One of the reasons for avoiding online forums was the amount of time it can take to get a response as most of the time the information our study participants were looking for was time sensitive. By the time there was a response to a post, the information might be irrelevant. Our participants expressed either a strong preference for online forums or did not use them at all. One professional stated their experience with the forum,

“I hardly ever rely on forums. There are a lot of opinions, you have to go through hundreds of posts. There are a lot of junk information and it takes so long to go through. Some people will speak non-sense, some will just respond to have their names on it. And only the off chance that you will get your answers on it.”

Reddit as source for security news and trends

Reddit is a social news aggregation and discussion website that is typically geared towards news and entertainment purposes. Only one professional in our interview mentioned that they use the site. P4 mentioned that he uses Reddit by searching through it for questions and answers that he is interested in. However, the author found that most of the posts on “information security” subpage are links to different security news and articles. There doesn’t seem to be much discussion going on within these pages, but rather the links are more useful as a way to get up to date on the latest security news and trends.

Blogs are commonly used for security news and updates

Blogs have been identified as a common resource for information. Blogs are typically written by security professionals who are at the top of their field. The top blog according to Feedspot, “We Live Security”, contains over 1.8 million Facebook members and contains articles written by a number of security experts. Other top blogs include “Krebs on Security” and “Schneier on Security”, which are written exclusively by individuals who run the blog. The professionals interviewed mentioned that they regularly read blogs. They choose blogs that are better known and avoid smaller blogs that aren’t as recognized. They do this by searching for the top blogs and choosing the most popular ones.

Discussion and Conclusion

This study looked at professionals and their use of the resources available to them in their daily work. The findings suggest that there is a well-defined method of information seeking and learning that has developed in the workplace that we studied. This process consists of utilizing

both interpersonal and online resources, depending on the requirements and information need of each specific situation. The information seeking process is triggered largely by the need to solve problems or by the interests of professionals in order to learn new knowledge in the field. Depending on the situation, professionals would map the requirements of what was needed to solve the problem, identified resources that were available, and then selected the best resource that would meet their information need. The process itself is iterative, with the professional utilizing multiple options in order to find the information they need, and to verify the information that was found. Our situated information seeking framework provides a model to look at other technology and information infused workplaces. Prior work on professional engineering learning has focused largely on the different kinds of skills and knowledge required to succeed in the workplace, such as concepts and communication skills, and how they can be translated into formal education. Our work extends that line of research by providing an information seeking perspective. This allows a better understanding of the current technology infused workplaces. Our work also contributes by outlining the specific resources that professionals use and their perceived advantages and disadvantages of those resources. We found that videos are a popular means of informal learning in the workplace but largely for problems that have a linear, step-wise solution. We also found that other people continue to be the primary resource of information for learning. One limitation of this work is that we have focused solely on informal learning experiences of professionals and our analysis lacks information on how these informal experiences interact with the various formal experiences – such as training – that professionals receive.

Acknowledgements

This work was partially funded by NSF Awards#1424444 and 1712129. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

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