Abstract

Educators are increasingly adopting inquiry-based learning as a way to engender higher order learning outcomes. To date, there has been a considerable debate about how to more effectively implement inquiry-based learning, such as technologies to adopt or professional development strategies. At the same time, libraries are also going through considerable changes due to the digitization of resources and the changing needs of patrons. Given that an important element of inquiry-based learning is information-seeking, we argue that the library is uniquely suited to collaborate with classroom instructors as they migrate towards problem-solving strategies in the classroom. Despite this natural collaboration, reform efforts in education and library science are considered in isolation. In this manuscript, we present research that suggests that libraries can best support inquiry-based learning by emphasizing the following: collaborative learning spaces, open-educational resources, and the development of research skills at different stages of problem-solving. Implications for practice are also discussed.

Introduction

Recently, educators have migrated toward inquiry-based learning strategies whereby learners self-direct their own understanding as they solve complex problems embedded within authentic scenarios (Lazonder & Harmsen, 2016; Loyens & Rikers, 2011). These student-centered instructional strategies, often defined as inquiry-based learning, pose some type of ill-structured case to the student and afford opportunities to generate a solution (Herrington, Reeves, & Oliver, 2014; Lazonder & Harmsen, 2016). While the discussion has often focused on ways to improve classroom instruction, the emphasis of inquiry skills also suggests a change in direction for librarians. Given the importance of self-directed inquiry and information seeking, libraries are uniquely skilled to support inquiry-based learning; indeed, the library science field has also undergone dramatic changes as technology catalyzed a transition towards more digital collection strategies (Glynn & Wu, 2003; Kennan, Corrall, & Afzal, 2014). In one recent survey, Cox and Corrall contend that the following specialities have recently emerged within the librarian
domain: “systems librarian, electronic resource librarian, digital librarian, institutional repository manager, clinical librarian and informationist, digital curator/research data manager, teaching librarian/information literacy educator, and information and knowledge manager” (p. 1526). Once again, these specialities have materialized as the educational needs have shifted, as well as the changing format of the resources themselves.

The emergence of inquiry-based learning and the changing role of the librarian signal an opportunity to collaborate; however, these changes are often discussed in isolation and irrespective of the other domain. We argue the recent focus on inquiry-based learning, self-directed learning and information seeking behavior suggests more interdisciplinary initiatives are required between classroom instructors and librarians. Future discourse is therefore needed about (a) how the migration towards inquiry-based learning requires educators to plan for supporting self-directed learning and (b) how librarians create settings for student-centered instruction. To explore this further, this manuscript first describes the theory and practice that serve as the foundation for inquiry-based learning. We then explore the role of the library and detail how the librarians are distinctly suited to facilitate this shift to inquiry-based strategies. Finally, we close with a set of recommendations about how to better position the library to support student learning as it relates towards collaborative learning spaces, open-educational resources, and the development of research skills.

Inquiry-Based Learning

One way to support 21st Century Learning Skills is through classroom practices that ask learners to solve contextualized, ill-structured problems (Herrington et al., 2014; Lazonder & Harmsen, 2016). Rather than focus on rote memorization, learners explore the elements of the problem space (concepts, features and goals central to the problem) as they develop solutions to resolve the issue (Hmelo-Silver, 2013). The generated solutions must also account for the differing perspectives, constraints, and alternatives that are inherent in the problem (Hmelo-Silver & DeSimone, 2013; Jonassen, 1997). Based on
situated learning theory, various instructional strategies have been developed, including problem-based learning (Barrows & Tamblyn, 1980; Lajoie et al., 2014), project-based learning (S. K. W. Chu et al., 2017; Wang, Huang, & Hwang, 2016) and others. Collectively, these approaches are often referred to as inquiry-based learning (Loyens & Rikers, 2011). Although variances may emerge in practice, inquiry-based learning generally consists of the following:

- Ill-structured problem
- Case-structured curriculum
- Collaborative Learning
- Reflective Learning
- Self-directed learning

Given that instruction in inquiry-based learning is student-centered, classroom instructors play a critical role in facilitating meaningful learning during inquiry. Classroom instructors encourage students to explore the problem space, engage in information-seeking based on emergent questions, and work collaboratively with groups. However, this shift presents multiple challenges. Despite instructors’ initial enthusiasm for inquiry-based learning, studies also show instructors struggle to apply the strategies and technologies as learners direct their information seeking and problem-solving (Ertmer & Ottenbreit-Leftwich, 2013; Haynes & Shelton, 2018; Wijnen, Loyens, Smeets, Kroeze, & Van der Mollen, 2017). This problem is further exacerbated given that educators have little professional development when new educational initiatives, such as NGSS, are implemented (deChambeau & Ramlo, 2017; Thomas & Watters, 2015). If this issue persists, instructors will be ill-equipped to build information-seeking and problem-solving competencies that are essential to a diverse 21st century workforce.

Alignment between instructors and Librarians
Much of the discourse about how to improve learning outcomes and apply inquiry-based learning has been situated within the educational domain. However, successful implementations of inquiry-based learning extend beyond just the classroom. As noted earlier, inquiry-based learning necessitates information-seeking skills as learners engage in the problem representation and solution generation phases (K. Chu & Wah, 2009; Cole et al., 2013). The migration towards inquiry-based learning thus elevates the library as an essential part of the pedagogical experience. According to Kuhlthau (2010), classroom instructors cannot effectively incorporate guided inquiry strategies until they see that:

*school librarians are vital agents in creating schools that enable students to learn through vast resources and multiple communication channels. Without this expertise, instructors can only minimally accomplish the information literacy requirement of 21st-century learning standards. Collaborations with instructors in a team can create the necessary climate for students to inquire, participate, create and learn in an information environment (p. 3).*

Therefore, classroom instructors should collaborate with librarians to align their strategies so learners are able to more effectively self-directed their problem-solving and information seeking behavior.

**Strategies to Align Inquiry-Based Learning and Libraries**

The digital age has transformed the types of resources, services and information delivery systems that libraries provide. Indeed, library science has begun to apply these principles through initiatives such as Makerspaces, the increase in electronic resources, digital libraries and metasearch strategies (Cox & Corrall, 2013). If librarians are to be “primary agents for designing new ways of learning” (Kuhlthau, 2010, p. 3), a siloed approach will not suffice and more collaboration between librarians and other educators is needed to facilitate instruction. In the following sections, we outline how librarians and classroom instructors can collaborate in terms of the following: libraries as collaborative learning spaces, libraries as access to open educational resources, and developing research skills.

**Libraries as Collaborative Learning Spaces**
Rather than see classrooms as the primary location where learning takes place, libraries can be seen as an extension of the overall inquiry and problem-solving experience. For instance, Williams and Willett (2017) contend that shared learning spaces are an opportunity for collaboration, which is critical for learning in ill-structured problem-solving. As in the case of Makerspaces, these collaborative learning spaces allow individuals to leverage tools and technology to create artifacts that represent their newly acquired knowledge. New tools and technologies that allow people to create in a structured environment, including 3D printers and Raspberry Pi kits, provides additional shared resources that support inquiry-based learning (Burke, 2014). Thus, the inclusion of Makerspaces in academic and public libraries has been suggested as a way of engaging and fostering collaborative problem solving within the library, while demonstrating the continuing value of libraries (Barniskis, 2016; Lee, 2017; Willett, 2017).

In contrast to a library strategy that focuses on access to static materials, collaborative learning spaces align well with inquiry-based learning strategies because they provide students the opportunity to construct tangible solutions within library settings. Specifically, libraries that equip the spaces with appropriate resources allows the student to actively engage with modern technology, explore problems, and develop creative solutions with their peers. Indeed, studies show patrons successfully develop creative skills when actively using library resources for problem-solving. For instance, Harron and Hughes (2018) found instructors that implemented a Makerspace reported improvements in student-centered instruction, application of knowledge, and opportunities to generate tangible solutions. Additional research reports learning outcomes in terms of idea generation (Hinton, 2018; Noh, 2017), collaboration (Barniskis, 2016), reasoning skills (Trust, Maloy, & Edwards, 2018), and professional identity (Baker & Alexander, 2018) when participants were able to employ collaborative learning spaces located within the context of a library. In doing so, the affordances of collaborative learning spaces uniquely positions the libraries to support different aspects of inquiry-based learning.
Despite the initial movement toward Makerspaces, research suggests additional attention is needed to better reimagine the libraries as more comprehensive collaborative learning spaces, especially as it relates to professional development of librarians (Hsu, Baldwin, & Ching, 2017; Oliver, 2016; Peterson & Scharber, 2018). This migration requires that librarians must be well-versed in the physical hardware, while also being able to facilitate students’ inquiry and information-seeking as they use the newly available library resources (Buchanan, Harlan, Bruce, & Edwards, 2016). That said, professional development for Makerspace learning is difficult to access and librarians are often dependent upon outside sources to assist patrons with their creative endeavors (Moorefield-Lang, 2015; Peterson & Scharber, 2018). This can lead librarians to feel overwhelmed and “under-prepared to offer skills and content in Makerspace programs or feeling that the role of the librarian is being undermined by expecting them to be experts in so many areas including making, pedagogy, and reference” (Williams and Willet, 2017, p. 8). Future research and collaborative efforts between librarians and classroom instructors is needed to best facilitate the implementation of inquiry-based learning (Lee, 2017; Oliver, 2016; Willett, 2017).

Libraries as Access to Open Educational Resources

Given the emphasis on information-seeking, research suggests that learners in inquiry-based learning rely more heavily on information resources when compared with lecture (Tawfik & Lilly, 2015; Wijnen, Loyens, Smeets, Kroeze, & van der Molen, 2017). While libraries serve as a valuable source for collaboration through Makerspaces and promoting ill-structured problem-solving, they also provide a wealth of digital educational resources to promote self-directed learning and information seeking through public domain assets. In years past, this was often through resources available in stacks or through digital subscription services. Moreover, these resources were often restricted by existing copyright laws, which required legal permission despite a legitimate claim for fair use. This, in turn, leads to a permission culture that focuses on resource protection over open access (Lessig, 2004). However, the digital age has
lead to increased accessibility of Open Educational Resources (OER), which provides a more expansive set of resources for students to access during the problem-solving. Because OERs are generated by the users and not restricted by tradition copyright licenses, OERs also provide an opportunity for students to create their own learning resource as a representation of their knowledge gains (Colvard, Watson, & Park, 2018) and share them with the broader educational community.

Prior required permission for use and distribution of digital resources, which limited information-seeking and ultimately learning outcomes in problem-solving. In contrast to copyright materials, most OERs are often accessible through a Creative Commons (CC) license, which allows creators to designate how their works can be accessed, reused and distributed by users. For example, if a student creates a medical animation or 3D diagram of a bridge, s/he could share this resource to a wider audience, provided they give credit and place an Attribution-NonCommercial license on the work. Using different CC license options, teachers could also release multimedia videos or lesson plans into the public domain so that other educators are able to use the resources for their own inquiry-based learning module. In doing so, the license options would allow the resource to be copied by and edited by other educators, while also providing proper attribution of the materials.

Libraries as access to OERs have various implications for both librarians and classroom instructors. In years past, librarians and classroom instructors have often directed students towards the more readily available, internal resources. Although Creative Commons has become more popular in recent years among digital libraries such as the Internet Archive, the emphasis still remains on access of existing materials rather than content creation (Baaki, Maddrell, & Stauffer, 2017). Furthermore, despite OERs growth over the past two decades, many students are unaware of traditional copyright laws and policies. As educators continue to implement inquiry-based learning, librarians can play an active role in educating students on how creators (instructors, students) can use OERs repositories to protect, but also share their knowledge artifacts created during their problem-solving. Further exploration regarding
development of OERs within library settings expands creative and critical thinking among new creators, while also sharing learning resources with the educational community at-large.

Role of the Library in Developing Research Skills

In years past, educators have seen the library as a set of resources that support their classroom instruction as-needed. In that model, the strategy of library curation was to identify relevant resources that aligned the general direction of classroom objectives. In many instances, collection management decisions were often made by working with departmental liaisons about which books were required for a given course topic. While this approach was designed to facilitate relationships between classroom instructors and librarians, these decisions were often lower in priority when compared with other teaching responsibilities (Poole, 2017; Richards, 2018). Moreover, the liaison was responsible for communicating with his/her colleagues, which is also often not a priority for the liaison. Finally, this apriori approach may be inconsistent with inquiry-based learning approach that asks students to dynamically develop and share their own learning resources encountered during information-seeking.

This importance of self-directed learning during inquiry-based learning presents new opportunities for librarians and classroom instructors to collaborate. Given the research that underscores the importance of information seeking (Loyens, Rikers, & Schmidt, 2006; Weiss & Belland, 2018; Wijnen, Loyens, Smeets, Kroeze, & van der Molen, 2017), librarians should explore ways to emphasize research skills and evaluation of digital resources. Moreover, librarians could espouse strategies that encourage differentiated information-seeking at specific stages of their problem solving, namely the (a) problem representation and (b) solution generation phases (Ge, Law, & Huang, 2016). The former requires learners to identify the relevant resources that are central to the problem space, related conceptual space, and causal mechanisms. The solution generation phase suggests that learners apply their newly acquired understanding towards a solution. Across each phase, learners generate answers to questions based on their knowledge gaps (Sullins & Graesser, 2014) and identify resources that answer the
questions. When their knowledge is applied, learners will determine the degree to which their proposed solution is viable. If it is not deemed viable, the student will engage in another cycle of problem solving and information-seeking given their increased understanding of the phenomenon.

Awareness of the information-seeking needs required at different problem-solving phases positions librarians to support student-inquiry in unique ways. First, librarians could encourage learners to leverage performance tools that allow curation of resources they deem relevant at distinct stages of their problem-solving (problem representation, solution generation phases). With the knowledge about how learners iterate problem solving, librarians could also adopt specialized content collection management strategies and cultivate information skills germane to each phase. In terms of the problem representation phase, libraries could explore ways to generate data literacy skills and search strategies so that the student inquiry fully considers the array of resources needed to investigate the problem space. As learners initially explore the problem space, libraries could then transition towards information-seeking behavior that allows learners to compare and contrast different perspectives found within the resources. As learners progress to the solution generation phase, the role of the librarian is to understand the set of resources that focus on students’ resolution of knowledge gaps and related resources that allow them to apply their knowledge. Given that inquiry-based learning strategies often encourage collaboration, they could also explore digital performance tools that afford opportunities to share knowledge artifacts with their peers at each stage. For example, a tool such as hypothes.is allows individuals to annotate digital tools and later circulate their findings as a way to catalyze discourse. Once again, these strategies signify a shift from resource access to one that better aligns with the student-centered and self-directed approaches accentuated in inquiry-based learning.

**Conclusion**

Hines and Hines (2012) contend that “it is a commonly held opinion among teaching faculty that the average college student lacks sufficient skill and training in critical thinking and information literacy”
Many cite evidence that the previous lecture-based approaches may disseminate information from the instructor to student, but they do not position the learner to apply their knowledge towards meaningful problems that practitioners face (Hmelo-Silver, Duncan, & Chinn, 2007; Leary & Walker, 2009; Wijnen, Loyens, Smeets, Kroeze, & van der Molen, 2017). Through initiatives such as the NGSS, educators are increasingly exploring classroom practices that expose learners to the types of ill-structured challenges that practitioners face. In doing so, many argue that learners are able to learn the content, while also generating additional problem-solving skills (Jonassen, 1997; Kim, Belland, & Walker, 2017).

This shift in educational strategies also coincides with changes in library science. In recent years, the usefulness of libraries has been questioned, as seen in the decreased percentage of academic institutions with libraries in recent years (U.S. Department of Education, 2014). In response to the changing landscape of collections, many libraries have expanded their access to modern technology and digital resources, as well as acquired the staff to help students improve their information seeking behavior. Despite reform efforts in both education and library science, models and theories that purport to improve education are often constructed irrespective of the other domain. A more interdisciplinary approach is thus needed about how those in library science can play a more pivotal role in the pedagogical strategies as institutions espouse inquiry-based and 21st century learning principles. Based on theory and research, we identify three opportunities that align libraries emphasis on information-seeking with the migration towards inquiry-based learning in education. The first suggestion, libraries as collaborative learning spaces, considers the library from a holistic perspective and how it can afford opportunities for collaborative knowledge building, application of knowledge, and generation of tangible solutions. Second, a greater emphasis on open-educational resources shifts the strategy from an access of existing, internal materials to one that emphasizes creation and distribution of new knowledge with other educators. In doing so, this affords the learner a platform to generate and share resources, while extending the collections beyond the often existing, limited subscriptions of the library. Finally, librarians can
support students through the development of research skills and information-seeking strategies at specific stages of their iterative problem-solving, namely the problem representation and solution generation stages. These strategies are just some ways in which educators can better collaborate with their library peers to promote inquiry-based learning and better catalyze higher order learning outcomes.


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