AN EXPLORATION OF ONLINE INFORMATION SPACES THAT SUPPORT INSTRUCTIONAL DESIGN AND TEACHER PROFESSIONAL DEVELOPMENT

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

AN EXPLORATION OF ONLINE INFORMATION SPACES THAT SUPPORT INSTRUCTIONAL DESIGN AND TEACHER PROFESSIONAL DEVELOPMENT

presented by Javier Leung,

a candidate for the degree of Doctor of Philosophy,

and hereby certify that, in their opinion, it is worthy of acceptance.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

ABSTRACT

Members in online communities of practice (CoPs) take advantage of information and communication technologies (ICTs) to exchange practical or work-related knowledge in asynchronous online environments. Practical knowledge represents individuals' mental models allowing them to interact with the environment and perform tasks. With ICTs, practical knowledge accumulates over time and becomes an integral part of online CoPs. Due to ease of implementation, content management systems (CMSs) and social media platforms, primarily Facebook, have enabled the emergence of large online CoPs.

However, research has shown that online CoPs are not conducive information spaces for seeking solutions independently, and hashtags used for topic organization are not representative of the wealth of practical knowledge. This three-article dissertation describes design recommendations for supporting the information needs of community members by analyzing the practical knowledge in instructional design and technology (IDT) that rely on a CMS and the Facebook platform and conducting usability testing to improve an existing teacher professional development CoP.

By applying natural language processing (NLP) and usability testing, quantitative and qualitative approaches were implemented to examine the practical knowledge and help guide the design of information spaces that enable members to search for solutions through better topic representations or categories. The results of the first study showed that the e-learning development CoP emphasized producing online articles related to educational technology and the lack of transparency in evaluating such materials. The results of the second study showed that the four IDT CoPs on the Facebook platform were characterized by the lack of effective topic structures representative of the

accumulated knowledge and the lack of community protocols for curating knowledge and taking corrective actions toward misinformation. The third study relied on usability testing to design an information space to support educators' ability to align materials with Missouri teacher standards.

This three-article dissertation suggests five design features that online CoPs can implement in addressing the shortcomings of asynchronous online environments, including (1) improving topic organization, (2) establishing community protocols, (3) increasing transparency, (4) improving search functions, and (5) leveraging NLP in future web technologies. Lastly, the dissertation discussed the results of the three published studies, offered recommendations for improving online CoPs as conducive information spaces, and provided future directions.

Keywords: Communities of practice; natural language processing; teacher professional development; instructional design and technology

Chapter 1: Introduction

Information and communication technologies (ICTs) provide boundless mechanisms for formal and informal engagement in synchronous and asynchronous online environments. ICTs are various tools and resources that store, create, share, and exchange information (Usun, 2009). The implementation of ICTs is diverse in different industries, including content management systems (CMSs), learning management systems (LMS), collaboration and communication tools, and social networking sites. Zuppo (2012) argued that ICTs impact the economic, education, business, and professional development sectors. ICTs in the economic sector, for example, provide governmental agencies and organizations with the ability to participate in the digital economy and connect with the rest of the world. In the education sector, ICTs enhance teaching, expand learning opportunities, improve curricula, promote access to education for marginalized groups, and enhance individuals' employability and skills. ICTs are a pivotal element in the business sector that allows for information processing and communication among public and private entities. Regarding the professional development sector, ICTs allow collaborations between scholars and industry practitioners to outline competencies and skills across different industries.

With the rise of ICTs using Web 2.0 technologies since 2004, individuals can quickly form online communities of practice (CoPs) using asynchronous and synchronous online environments to support sharing tacit or practical knowledge using CMSs and social media networking sites (Önday, 2019). CoPs are groups of people who engage in collective learning in a shared domain (Wenger, 2011). A few examples of CoPs using asynchronous online environments are open-source CMSs (e.g., Joomla and

Drupal) and social media networking sites (Facebook, Twitter, Reddit, LinkedIn) that facilitate the creation and dissemination of practical knowledge. Wagner and Sternberg (1985) defined tacit knowledge as work-related practical knowledge learned informally through experience on the job concerned with knowing how instead of knowing what. Al-Qdah and Salim (2013) suggested that categories of tacit knowledge are based on levels of articulation, including tacit knowledge that can either be fully or partially articulated or deeply ingrained. Abidi et al. (2005) divided tacit knowledge into basic and complex categories. Basic tacit knowledge is conveyed by casual conversations and questions and becomes articulated or explicit knowledge, whereas complex tacit knowledge is deeply embedded in experts' minds. Collins (2010) further argued that tacit knowledge could be categorized into relational, somatic, and collective tacit knowledge. Relational tacit knowledge is the type of knowledge subject to interpersonal interactions. Somatic tacit knowledge consists of inherently embodied knowledge and is limited to physical movements (e.g., maintaining balance while riding a bike). Collective tacit knowledge refers to the knowledge that is ingrained in society's cultural norms. Collins suggested that relational and somatic tacit knowledge can be codified or articulated, whereas collective tacit knowledge is context-dependent and cannot be codified.

Problem Statement

ICTs are currently built on Web 2.0 technologies emphasizing the creation and distribution of content (Önday, 2019). ICTs have allowed the accumulation of practical knowledge in online CoPs as the byproduct of members' interactions. Erickson and Kellogg (2000) argued that knowledge production is deeply entwined with the dynamic nature of online CoPs as community members co-produce, share, and discover

knowledge. Furthermore, the accumulated practical knowledge is deemed an organizational asset and represents the organizational knowledge capital in online CoPs. However, previous studies have documented the navigation challenges that community members face when accessing the accumulated practical knowledge in online CoPs. While the organization of tacit knowledge is critical in online CoPs, organized tacit knowledge can become a critical asset that improves individuals' quality of work, decision-making, and performance accuracy (Brockman & Anthony, 2002; Suppiah & Sandhu, 2011). When effective mechanisms are implemented to organize the wealth of tacit knowledge, individuals are better positioned to have more rich professional experiences as they improve their cognitive abilities, somatic skills, and mental and physical perceptions. (Kabir, 2013; Kogut & Zander, 1992).

Although ICTs play a critical role in supporting the creation and distribution of practical knowledge, online CoPs have inefficient organizational schemes that mismanage the accumulated practical knowledge with little or no alignment to professional competencies. The lack of organizational schemes affects community members' ability to search for solutions independently, allowing for professional advancement from content- and contextual-based organizational perspectives. First, the literature has noted the usability issues in online CoPs' lack of mechanisms for browsing the accumulated practical knowledge from a content-based organizational perspective. Second, online CoPs are not designed as information spaces that enrich the professional advancement of community members by contextualizing tacit knowledge with professional competencies.

Community member participation has been studied in five levels of social network engagement in online CoPs, including identifying, lurking, contributing, creating, and leading (Dawley, 2009). Although most community members consist of "lurkers," or those who exhibit peripheral participation and observe how members interact and learn from information exchange, "lurkers" are likely to rely on the organizational and search mechanisms to navigate the accumulated practical knowledge in online CoPs without full participation (Marett & Joshi, 2009; Muljana et al., 2021; Rafaeli et al., 2004). Although ICTs have enabled practitioners to develop online CoPs out of shared practice and necessity, future technologies should support community members' information tasks through organizational schemes that allow for topic categorization and evaluation of tacit knowledge based on professional competencies. This dissertation explores the mechanisms to support the navigation and evaluation of the accumulated practical knowledge ingrained in online CoPs as mental models and shared beliefs, identities, and meanings.

Theoretical Foundations

The following literature review describes critical concepts to consider in the context of the three-article dissertation. These concepts are related to CoPs, the role of technology in sustaining communities, the extraction of tacit knowledge from codified knowledge, and the theoretical framework for understanding knowledge creation and sharing.

Communities of Practice

Wenger and Synder (2000) described CoPs as groups of people informally gathered to share expertise in a specific domain or field as they interact regularly.

Zappavigna (2006) stated that CoPs hold collective meanings and processes of acculturation where members internalize the group's norms and implicit knowledge structures. Wenger and Snyder (2000) asserted that members of a CoP engage in informal interactions to enhance self-reflection.

While CoPs hold shared beliefs, identities, and meanings (Campos et al., 2011), CoPs become successful when addressing the social, cultural, and organizational issues rather than the technical aspects of collaboration. According to Lave and Wenger (2001), thriving CoPs are characterized by time and space (presence and visibility, and rhythm), participation (variety of interactions and efficiency of involvement), value creation (short-term value and long-term value), connections (connection to the world), identity (personal identity and community identity), community membership (belonging and relationships, and complex boundaries), and community development (evolution and active community-building).

In terms of time and space, CoPs need a presence, visibility among members, and rhythm that affirms shared values and meaning through events and rituals. Thriving CoPs should provide a variety of interactions that allow all members to participate. In value creation, CoPs provide short-term value to members' organizational contexts and long-term value to the long-term development of members' knowledge. Another way to provide value is to connect with larger communities that align with their shared domain and practice. In addition, members have personal and communal identities that define them as competent practitioners and collaborators in their respective communities. Community members' interactions and trust among colleagues are valued at different community levels. Also, Wenger (2011) noted that CoPs could have complex boundaries

where members could create sub-communities with particular aspects of shared practice. As CoPs evolve into mature and active collaborative environments, CoPs rely on making new connections, and members take on more responsibility to further develop communities.

Life Cycle of Communities of Practice

Brown and Duguid (1991) stated that knowledge creation in CoPs is characterized by three elements, including narration, collaboration, and social constructivism. In the first element, the narrative identifies problems in practice and seeks possible solutions from existing knowledge repositories. The second element is collaboration, in which community members engage in the exchange of knowledge. In the third element of social constructivism, members of a CoP develop a shared repertoire for solving problems.

Wenger (1998) outlined the lifecycle process of CoPs in five stages, including potential, coalescing, maturing, active, and dispersed. Throughout the stages, individuals face similar problems and find an emerging point for forming CoPs. As CoPs mature, CoPs set standards, structures, and relationships among members, creating an environment for shared practice and knowledge creation. However, when CoPs are no longer active, CoPs become a knowledge repository. Ray (2006) argued that CoPs contain the intellectual capital of collective human intelligence. Even if members of CoPs are no longer active, knowledge cannot cease to exist.

Sustaining Practice in Communities of Practice

CoPs thrive when community leaders are engaged in a balanced approach in all three dimensions (i.e., domain, community, and practice) (Stuckey & Smith, 2004; Wenger et al., 2002). Campos et al. (2011) stated that CoPs are operational and practical

instruments for knowledge development to support the intellectual development of the CoP. Also, knowledge development is characterized by intangible processes of transference and exchange among community members. CoPs require three essential elements to support knowledge development, including technology, organizational culture, and management model (Campos et al., 2011). Technology is a necessary element to support the operational aspects of knowledge development. The organizational culture establishes an online CoP's identity, codes of conduct, incentives, and recognition. The management plan identifies the processes of knowledge development, roles of actors, and types of knowledge shared or created.

Fung-Kee-Fung et al. (2011) suggested that a critical aspect of sustaining CoPs is social facilitation that encourages a collaborative environment. The authors proposed documenting social facilitation processes under four categories, including innovation, knowledge transfer, social capital, and organizational memory. Innovation occurs when community members generate ideas to solve shared issues. Knowledge transfer refers to converting explicit to tacit knowledge (i.e., internalization process in SECI), where members incorporate explicit knowledge into their practice. The SECI model explains four knowledge dimensions (i.e., Socialization, Externalization, Combination, and Internalization) where tacit or practical knowledge is converted into explicit or codified knowledge (Nonaka & Takeuchi, 1995). Social capital is defined as the rules and norms for shared practice (e.g., professional development events and networking events) and how members solve problems collaboratively. Organizational memory refers to the accumulated collective knowledge of a CoP to solve shared issues and their solutions based on collective knowledge.

Communities of Practice and Other Types of Communities

Sanz and Pérez-Montoro (2011) argued that CoPs are often confused with other types of communities (e.g., learning communities or communities of interest) and organizational-related communities or structures (e.g., working teams, formal and informal communities). The consensus is that CoPs are individuals who live under similar circumstances and rules, whereas groups and teams are bound to provide specific research or service. CoPs are also confused with learning communities and communities of interest. Learning communities are the contexts in which students are brought together to learn through participation and involvement. Communities of interest are individuals who share a common interest or passion unrelated to professional practice. CoPs possess two characteristics related to cohesion and time limitation or duration of the group. First, members share their professional practice with colleagues and benefit from the expertise of others. Second, members remain part of the CoP because of their interest and commitment to sharing professional practice. Membership in other organizational structures (e.g., learning communities, communities of interest, and formal and informal and formal groups) ends when learning objectives, interests, or solutions are attained. In contrast, membership in CoP continues due to ongoing shared practice.

Technology to Sustain Communities of Practice

With the evolution of web technologies, online CoPs can increase their presence beyond geographic boundaries, allowing community members to participate in shared spaces for knowledge creation and transfer. In the early days of web technologies, Web 1.0, also known as the web of reports, was originated by Tim Berners-Lee in late 1989. Organizations can only read static data for reporting purposes on HTML pages (Berners-

Lee, 1996; Önday, 2019). With the inception of Web 2.0 in 2004, web technologies allow individuals to create and distribute content. Examples of Web 2.0 platforms are social networking sites (e.g., Facebook, LinkedIn), blog platforms (e.g., Blogger, Reddit, WordPress), CMSs (e.g., Drupal, Joomla, Canvas, Blackboard), LMSs (e.g., Canvas, BrightSpace, Blackboard) and photo and video platforms (e.g., Instagram, YouTube) that rely on web technologies, including Ajax, JavaScript, Cascading Style Sheets (CSS), Document Object Model (DOM), Extensible HTML (XHTML), and XSL Transformations (XSLT)/XML. Web 3.0, also known as the semantic web, was the third era in 2006 and attempted to connect, coordinate, and ensure the quality of multiple data sources to create new data streams. The future of the web is considered an ultra-intelligent agent (Web 4.0) and combination web (Web 5.0), where web technologies can create analytical insights and oversee extensive server data with flexible designs. While online CoPs depend on web technologies to provide shared spaces of collaboration, their knowledge creation and sharing will partly depend on how web technologies are implemented with effective information architectures (IAs). While Web 2.0 technologies have enabled the accumulation of practical knowledge due to community members' interactions, an analysis of the accumulated practical knowledge through natural language processing (NLP) is a foundational step in establishing IAs or topic structures representative of online CoPs.

Online CoPs act as integrated information spaces where community members can access information in multiple ways (e.g., desktops, tablets, and smartphones) (Ding & Lin, 2009). As information spaces, the design of online CoPs can either facilitate or hinder users' ability to create, share, and reuse practical knowledge. Studies in

information systems aim to analyze the dissemination of knowledge within and among online CoPs by understanding the boundary objects and interactions that enable knowledge transfer. Wenger (1998, 2011) described boundary objects as repositories or artifacts that facilitate articulating knowledge and have recognizable meanings within a CoP. These boundary objects are syntactic, semantic, and pragmatic (e.g., documents, forms, models, maps) that facilitate transforming knowledge (Carlile, 2002). Wenger also highlighted the concept of boundary interactions, where members connect to exchange knowledge.

Oyarzun et al. (2011) argued that Web 2.0 provides advantages and disadvantages to online CoPs. First, community members can access online CoPs anytime, but their motivations or reasons for accessing resources vary over time. Second, community members with different expertise and knowledge can contribute to new ways of solving problems. However, the lack of face-to-face communication can contribute to social isolation. Third, online CoPs deployed on Web 2.0 technologies are scalable and cost-effective, but the technology is not always user-friendly and may prevent members from participating. Carlén et al. (2004) acknowledged that online CoPs are extensions of traditional communities, and Web 2.0 tools act as support for activities.

Even though Web 2.0 is a critical component of online CoPs, Seufert et al. (2002) proposed a reference model for designing online CoPs that focuses on collaborative learning by examining three frames, including actors, activities, and tools. First, the actors are the participants and non-participants in the community. Based on the level of engagement and expertise, actors can be main characters (e.g., students who take direct participation, managers (e.g., facilitators and creators of the CoP), and stakeholders (e.g.,

stakeholders who are indirectly involved in activities). Second, activities reflect the community activities that take place both purposely and unplanned. Activities can be further categorized as initiation and governance, access, and membership. The first type of activity refers to the rules, norms, and educational outcomes of the CoP. The second type is initiation, where members get acquainted with one another through socialization. The third activity is membership, in which members focus their interactions on sharing, exchanging, and transforming knowledge. Lastly, the tools frame supports actors and the different types of activities. When using the reference model by Seufert et al. (2002), Carlén et al. (2004) asserted that the three frames (i.e., actors, activities, and tools) are interrelated and support each other. If changes to a frame are implemented, it will affect the other two frames.

Furthermore, the first challenge in sustaining online CoPs is the withdrawal or attrition of members (Haythornthwaite, 2000; Johnson, 2001). Mohamed et al. (2004) argued that text representations in online CoPs tend to be unclear and require extensive member participation to support ongoing discussions. The second challenge is the lack of discoverability of knowledge. The lack of discoverability of knowledge prevents members from making representations of social knowledge within the online CoP and understanding how social knowledge is evolving.

Tacit Knowledge Sharing, Quantization, and Generation

Tacit knowledge is studied extensively across disciplines. Hao et al. (2016) proposed a way to explore tacit knowledge in four research areas, including tacit knowledge sharing (TKS), tacit knowledge quantization (TKQ), tacit knowledge generation (TKG), and tacit knowledge engineering (TKE).

TKS refers to the body of work in management science investigating influential factors and mathematical models for sharing tacit knowledge among individuals within an organization. The level of TKS depends on several factors that affect sharing of tacit knowledge based on reported factors, including trust, conflict, culture, well-being, and social relationships. While tacit knowledge is not studied and ignores its structure and representation in TKS, studies in TKQ aim to extract and make readable representations of tacit knowledge from artifacts and individuals. Studies in TKQ focus on three existing methods, including expert location, knowledge extraction, and knowledge representation. Expert location refers to the direct identification and measurement of experts' knowledge. In contrast, knowledge extraction and representation are indirect methods that rely on computation methods for representing hidden patterns of tacit knowledge.

While the results of TKQ or the representations of tacit knowledge from artifacts, the quantized results of TKQ are static, and their representations cannot be upgraded during the generation of tacit knowledge. TKG is concerned with generating tacit knowledge by designing the model-environment interaction using machine learning (ML) models and algorithms to understand the storage and learning mechanisms of tacit knowledge generation. TKE refers to the cognitive mechanisms of tacit and computational models to support software systems in generating tacit knowledge. In TKE, software systems emulate the cognitive cycle of intentional action, multisensory perception, comparison of perception and goal, incorporation of comparison results, and repetitions of previous steps.

In TKQ studies, NLP algorithms are implemented in the knowledge management literature. These algorithms elicit, extract, and represent tacit knowledge from individuals

and artifacts to create question-answering systems to support employees. For example, Stone and Sawyer (2006) performed a latent semantic analysis (LSA) to extract the tacit knowledge from stakeholders' and experts' elicitation records, such as interviews and ethnographic reports, as part of pre-requirements tracing in software development. Mohanan and Samuel (2016) applied open natural processing and semantic business vocabulary and rules to generate user and software requirements and relationship attributes among objects.

Satsansgi (2019) argued that workers' insights and understanding of problems are present in information systems that capture project updates. By summarizing the project updates using the Natural Language ToolKit (NLTK) and other libraries for processing textual data, tacit knowledge extraction is used to develop a predictive algorithm that anticipates issues and solutions. Jackson et al. (2012) developed a question-answering system for existing employees by extracting knowledge from previous experts and clients from email communications using NLTK. Although unstructured data is the primary source for discovering tacit knowledge from text artifacts, Chen and Saeedi (2004) analyzed web server logs and text queries with a Bayesian probabilistic model to identify the implicit navigation, search patterns, and short-term information needs of library users.

Dudek and Patalas-Maliszewska (2016) extracted tacit knowledge from explicit knowledge from audio and video recordings in a manufacturing service department. The Google Speech application programming interface (API) was used to transform audio and video information for automatic speech recognition, object recognition, and NLP. The authors modeled tacit knowledge structures using the vector representation from acquired recordings. Kim and Chi (2019) developed models for retrieving critical information

about construction accident cases and classifying the nature of the incident for safety management. The authors extracted the semantic similarities found in accident reports in two ways, including a rule-based method and ML. With a rule-based approach, information is extracted from an established pattern, whereas in ML, the algorithm learns the structure and extracts semantic relationships from the text.

NLP algorithms are also used to identify patterns in knowledge domains and online CoPs. Wei et al. (2008) implemented multilingual document clustering and latent semantic indexing (LSI) to create knowledge maps and patterns from organizational records. Veremyev et al. (2019) explored word2vec embeddings and graph theory tools to construct semantic networks that capture the context of words, semantic and syntactic similarities, and object relationships found in the corpora of Google News and Amazon reviews. McArthur and Bruza (2003) implemented LSA to represent the meaning of words and their implicit associations in online CoPs. The authors argued that semantic structures represented the tacit knowledge structures of the online CoP. Novak et al. (2002) analyzed tacit knowledge structures in different online CoPs through various visualization modules and a Support Vector Machine (SVM) to classify themes and cluster similar content.

To sum up, NLP algorithms are widely used unsupervised to identify the patterns in tacit knowledge from the codified language in documents and communication. While LSI and LSA are widely implemented in studies, this three-article dissertation uses the Latent Dirichlet Allocation (LDA) and NLTK to extract syntactic, semantic characteristics for quantifying tacit knowledge. Also, LDA and NLTK are commonly

used to develop APIs that process textual data to support the organization of tacit knowledge.

Theoretical Framework

Research studies in the knowledge management literature examine tacit knowledge extraction from explicit forms of knowledge in the workplace (e.g., online platforms, documents, and e-mail communication). These studies are explored through the SECI model, where knowledge is continuously created through Socialization, Externalization, Combination, and Internalization (Nonaka & Takeuchi, 1995):

1. Tacit knowledge is created through socialization, and its tacitness is difficult to codify into explicit knowledge.
2. Tacit knowledge is externalized or articulated in symbolic language for sharing with other groups or individuals.
3. The combination step requires applying and reorganizing explicit knowledge.
4. When explicit knowledge is applied, individuals embody the knowledge as tacit through action and reflection.

Nonaka and Takeuchi (1995) also elaborated on the concept of *ba,* or *basho,* as a context for shared knowledge creation and relationship building between individuals within organizations. *Ba* can be a physical, online, and mental shared space of interaction (Meloni & Villa, 2007). Four types of *ba* exist to support each phase of knowledge conversion. The first type is the originating *ba,* which supports the socialization processes where individuals can share tacit knowledge with a deep interchange of experiences and mindsets. The second type is the interacting or conversing *ba* that supports the externalization process, where tacit knowledge is transformed into explicit knowledge

and individuals exchange dialogue in verbal or written forms. The third type is the cyber *ba* that supports the combination process where explicit knowledge can be organized and disseminated through ICT solutions and facilitating group-to-group communications. The fourth type is the exercising *ba,* which supports the internalization process where individuals embody explicit knowledge by making it personal tacit knowledge and enhancing the acquisition of new knowledge for self-refinement.

The concept of *ba* has been used in the research of CoPs in knowledge creation and sharing situations (Cairns & Malloch, 2011; Mäkäräinen-Suni & Hong, 2011). *Ba* and CoPs share similar characteristics, including bringing individuals with similar interests, being willing to share knowledge and practices, and being part of a community or shared space. Even though the concept of *ba* and CoPs share similar characteristics, significant differences for *ba* include the creation of new knowledge in a fluid environment with changing members, whereas, in CoPs, knowledge is embedded with members within clear boundaries of interaction with a stable membership of individuals (Mäkäräinen-Suni & Hong, 2011). Wenger and Synder (2000) described CoPs as groups of people informally gathered to share expertise in a specific domain or field as they interact regularly.

This three-article dissertation connects to the SECI model, where the knowledge creation process in online CoPs operates under their established goals and depends on their processes for sharing and creating knowledge using web technologies. The first study aims to extract tacit knowledge from an e-learning news outlet called elearningindustry.com. This site is one of the largest communities for producing and sharing practical knowledge in instructional design and technology (IDT). IDT

practitioners are invited to write online articles under multiple categories. The e-learning news outlet CoP relies on a CMS platform where online articles are deployed under different categories and approved by community administrators. The second study aims to extract tacit knowledge from four public Facebook groups. Two online CoPs are related to IDT, and the other two groups are related to e-learning authoring tools (e.g., Adobe Captivate and Articulate Storyline). Community members can ask for professional advice, share new knowledge with others, and hold discussions about best practices and issues in the domain of practice. Community posts and discussions do not require formal approval by administrators. Community members can also exchange professional knowledge through the group's Facebook feed. The third study aims to redesign an online teacher professional development platform, the EdHub Library, as an online information space that allows educators to align professional development materials with Missouri teacher standards. The EdHub Library is a knowledge repository in which experts' knowledge is captured and translated into e-learning modules and activities. Self-paced professional development materials are organized under multiple categories aligned to Missouri teacher standards using HTML pages, sitemaps, and a search engine.

Rationale and Contribution

Schwier et al. (2004) studied the characteristics and challenges of IDT CoPs. First, these CoPs are born of convenience rather than formal structures. When CoPs are convenient to use, they are seen as being of greater value. Their findings suggested that community members either succeed or fail in having meaningful conversations in asynchronous online environments. Also, the authors pointed out that asynchronous

online environments lack the mechanism for handling and filtering shared knowledge, or social capital, of the group within the environment.

While NLP methodologies are widely used in the knowledge management literature, NLP techniques showcased in this dissertation contribute to the fields of information science and human-computer interaction (HCI) to further analyze the knowledge creation and sharing capabilities of online CoPs and the interactions between individuals and online environments (Taskin & Al, 2019). The need for NLP techniques used in the first two studies stems from the lack of investigations of practical knowledge generated in ICTs that holistically investigate the accumulated practical knowledge as the byproduct of community members' interactions in online CoPs.

While HCI methodologies are traditionally used in examining various dimensions of usability and making recommendations of organizational schemes and tools for improving user experience, NLP techniques complement research efforts in other fields by investigating the knowledge generated by users as a direct use case of how community members use online environments. More specifically, the research contributions of the application of topic modeling techniques on the accumulated practical knowledge provide a critical foundation to uncover the additional use cases, personas, and organizational schemes that emerge from the analysis of the accumulated practical knowledge. With the advances in NLP, it is now possible to analyze large-scale textual datasets occasionally to uncover emerging or declining themes in practical knowledge that provide additional insights about the community members' discourse and codification of practical knowledge (Scaccia & Scott, 2021). More importantly, the findings of the studies contribute to developing next-generation ICTs with more robust functionality of tools and

organizational schemes that enhance online CoPs' capabilities for creating, sharing, and monitoring practical knowledge more effectively at the externalization and combination stages of the SECI model.

The significance of the studies in this three-article dissertation involves generating design recommendations for knowledge discovery in asynchronous online environments in IDT CoPs and documenting online CoPs' shared knowledge that builds the foundation for developing taxonomies or classification schemes in future studies. More specifically, the following studies provide an exploration of shared knowledge and practices in online CoPs and fill a gap in the literature in the following manner:

- **Study #1 E-Learning News Outlet CoP:** This site has its IA in seven news categories. Though practitioners are invited to write for the CoP, it is not clear how community administrators choose and verify the quality of the articles. While the site's structure helps organize its knowledge, additional structures within each category are needed to facilitate practical knowledge and skills development.
- **Study #2 IDT CoPs on Facebook:** Members are not obligated to participate, and the problem is that discovering existing knowledge within the online CoP is challenging. Designing an online CoP as an online information space and implementing curation practices should enhance community members' ability to find the answers independently and take a better inventory of their social capital.
- **Study #3 EdHub Redesign:** This paper is an example of designing an online information space for a specific CoP in K-12 within the Network for Educator Effectiveness (NEE) that aligns with the Missouri teacher standards. This study contributes to the teacher education literature by implementing several

mechanisms to support educators' information needs in standards-based teacher professional development.

Central Research Question

The following research question encapsulates the purpose and sequence of this three-article dissertation: What design features in online information spaces enhance the exchange of skills and knowledge among members of a community of practice?

The sequence of the papers describes the processes for taking inventory of shared knowledge from CoPs that allows for the creation of mechanisms to represent and visualize knowledge. Studies #1 and #2 describe NLP tasks for extracting topic structures from codified knowledge found in platforms that use different IAs to organize their practical knowledge. In study #1, the e-learning news outlet is structured into seven major categories. The topic representations of each category allow for further exploration within their existing structure. In study #2, CoPs using social media platforms (i.e., Facebook) do not have an IA that allows members to browse the available knowledge. The topic representations of these public groups allow for a mechanism to locate specific knowledge rather than rely on members' responses in an asynchronous online environment. Study #3 aims to improve the usability of an online teacher professional CoP that allows educators to align professional development materials with Missouri teacher standards regardless of experience in teacher professional development. Table 1 summarizes the overarching research question and the individual characteristics of each CoP with the respective research questions.

Table 1.

Central Research Question and Sequence of Studies

Central Research Question				
What design features in online information spaces enhance the exchange of skills and knowledge among members of a community of practice?				
Study/CoP	**Audience**	**Platform**	**CoP Goal**	**Research Questions**
1. E-learning News Outlet E-Learning Industry	Instructional Designers and E-Learning Developers	CMS	Publishing platform of online articles by practitioners related to workplace learning, online training, etc.	**RQ 1:** What are the most frequent words and word sequences used in online communities? **RQ 2:** What are the characteristics of sentiment, named entities, and relationships among entities in online communities? **RQ 3**: What latent topic structures exist in online communities?
2. Four Public Facebook Groups Two Instructional Designer Groups Two E-Learning Groups	Instructional Designers and E-Learning Developers	Facebook	Exchange information and resources related to IDT	
3. EdHub Library Redesign EdHub Library NEE	School administrators and teachers in NEE	Custom HTML pages and Cascading Style Sheets (CSS)	Provide standards-based professional development materials	**RQ 1**: In what ways can users' information needs be supported in locating standards-based teacher professional development materials regardless of users' experience in teacher standards and teacher professional development?

Methodological Foundations

This three-article dissertation uses quantitative and qualitative approaches to examine the practical knowledge of online CoPs in IDT and design an interface that supports the information needs of educators. The purpose of the three-article dissertation is to generate design recommendations to support online CoPs as information spaces that enhance the creation, sharing, and evaluation of practical knowledge. In achieving this purpose, the examination of practical knowledge in online CoPs is required to understand the purpose, functions, and how community members produce and exchange practical knowledge in CMS and social media platforms. The first study examined the practical knowledge produced across seven news categories in e-learning development using a CMS as the primary mechanism for producing and sharing practical knowledge. The second study explored the practical knowledge of four online CoPs in IDT on the Facebook platform. The third study examined the custom development of an information space to support a CoP of educators in Missouri.

Differences Amongst Data, Information, and Knowledge

ICTs have allowed for data, information, and knowledge transfer in online CoPs without geographical boundaries. Bergeron (2003) and Probst et al. (2000) provided vital data, information, and knowledge definitions. Data is numerical quantities or attributes from observation, experiment, or calculation. Information is data in a context where data is collected to provide explanations and interpretations concerning a particular object or event. Knowledge is information that is organized, synthesized, and summarized to

enhance comprehension, awareness, or understanding. Knowledge contains truths, beliefs, concepts, and perspectives about social groups and individuals (Stenmark, 2022).

In this three-article dissertation, knowledge is framed as practical knowledge in IDT for studies #1 and #2, where community members use their respective online CoPs to seek advice about educational technology implementation and solve issues related to instructional design projects. In study #3 of the teacher professional development CoP, the practical knowledge represents the effective implementation of teaching practices aligned with Missouri teacher standards. Although highly embodied practical knowledge is difficult to articulate or transfer to others explicitly when physical movements are involved, practitioners in online CoPs can still fully or partially articulate practical knowledge through asynchronous tools (Polanyi, 1966). Also, practical knowledge can be viewed as a continuum with structured, codified, or explicit knowledge at one extreme and unstructured, uncodified, or tacit knowledge at the other end.

Although data, information, and knowledge have been defined in the knowledge management literature, these elements are not isolated but work together where data and information are further externalized and combined to bring forth practical, valuable knowledge to practitioners for solving problems (Liew, 2007). As practical knowledge becomes internalized through practice, reflection, or learning-by-doing, practitioners break down practical knowledge back to data and information that serve as building blocks for building new practical knowledge through collaboration in online CoPs as part of the knowledge creation process (Nonaka & Takeuchi, 1995). Davenport and Prusak (1998) also stated that practical knowledge is a mix of framed experiences, values, and

expert insight that provides a framework for evaluating and incorporating new experiences and information.

The practical knowledge can also be seen as intellectual capital stored in online CoPs. Intellectual capital comprises human and structural capital (Ronen & Pasher, 2011). Human capital represents practitioners' skills and expertise in a particular field. In contrast, the structural capital is the online CoP's technological capabilities and processes to support the community members' articulation, exchange, and management of practical knowledge. Although the management of practical knowledge is technology-dependent, online CoPs can still ensure their longevity and success by implementing processes for better elicitation, articulation, and management of practical knowledge (Bergeron, 2003). Without processes in place to manage practical knowledge along with enabling technology, online CoPs are not able to fully leverage the human capital aspect. Probst et al. (2000) also argued that the lack of transparency and visibility of practical knowledge hinder CoPs' abilities to self-assess their existing intellectual capital and adapt existing solutions to future problems.

While the dynamics exist amongst data, information, and practical knowledge, the data cleaning procedures ensured that the data sources were related to practical knowledge instead of merely sharing data and information on CMS and social media platforms. More specifically, study #1 contained online articles related to the knowledge about IDT practice and practitioners' perceptions toward educational technology and pedagogical concepts. The documents attached to online articles were excluded because they contained factual information about educational technology. In study #2, user posts that contained clear evidence of knowledge in the form of pedagogical and educational

technology advice were included in the analyses. User posts in the form of salutations, links to resources, and self-promotion ads were excluded due to the lack of contextual attributes when users sought advice from others in Facebook groups.

In the first two studies, NLP was employed as an exploratory means to examine the practical knowledge behind codified language in prominent online CoPs in IDT. Syntactic and semantic NLP tasks were implemented to extract the syntax-based characteristics and meaning behind text sources.

Syntactic NLP tasks refer to the characteristics of the syntax of words concerned with the position of words in a sentence without understanding the context around them. In these studies, the syntactic NLP tasks included average word and sentence lengths, n-grams, and word frequencies that allowed for exploring the codified knowledge from text sources. Lambda functions were used to calculate the average word and sentence lengths, and the visualizations were generated using the Profile Report package (Brugman, 2021). The n-grams language model in NLTK was implemented to understand the probabilities of contiguous words in trigrams and 4-grams (*Natural Language Toolkit — NLTK 3.6.2 Documentation*, n.d.). After implementing a stop words dictionary to remove uninformative words, word frequencies were obtained to understand the importance of words based on frequencies.

Semantic NLP tasks are concerned with extracting meaning out of the context of words. The semantic NLP tasks included sentiment analysis, named entity recognition and entity relationships, and topic modeling. The TextBlob package was implemented for sentiment analysis to identify positive, neutral, and negative attitudes in the texts (Lorian, n.d.). Text sources were processed with the spaCy package to extract entities, including

names of people, places, organizations, and geographic locations (*spaCy · Industrial-Strength Natural Language Processing in Python*, n.d.). Once entities were extracted, subject-object relationships were formed as entity pairs to describe the source and target entities linked by edge entities.

LDA and BERTopic were implemented for topic modeling to identify the latent topic structures in online CoPs. In the first topic modeling technique, LDA generated topic models based on the word representations and probabilities from the bag-of-words (BoW) and Term Frequency-Inverse Document Frequency (TF-IDF) (Řehůřek, 2009). In the second topic modeling technique, BERTopic was implemented to generate topic representations against a pre-trained model (Grootendorst, 2020; Reimers, 2021).

Although there is no standard evaluation procedure for topic modeling, semantically coherent topics were examined through human judgment and quantitative approaches. Chang et al. (2009) proposed evaluating topic model outputs using two methods, including topic and word intrusion methods. In terms of topic intrusion, discovered topics can be evaluated to determine whether the topic model's decomposition of documents agrees with human judgments. A topic model can be examined in terms of word intrusion by observing the words inserted in a topic model that do not provide semantic coherence or coherent meaning. Regarding the quantitative approach, coherence values were obtained by running the topic modeling algorithms until the highest coherence values were achieved.

Usability Testing

In the last study, redesigning the online teacher professional development platform, the EdHub Library, required two usability testing sessions through voluntary

participation from NEE and Assessment Resource Center (ARC) staff. This study was conducted as part of my employment duties as an instructional designer for improving a university-related service to school districts. Participant information was not collected, and no identifiable information can be traced back to participants.

The primary objective of the usability testing sessions was to obtain feedback from participants to refine the three-level hierarchical navigation structure of the prototype. The prototype contained three main sections (i.e., getting started, search engine feature, and topic categories). In the first usability testing session of the prototype, five NEE trainers were given a task to look for specific materials, write the location of the materials, and provide feedback related to their user experience (UX).

After implementing feedback from the first usability testing session, the second prototype incorporated a fourth section for accessing dedicated NEE teacher indicator sitemaps directly from the homepage. To verify the correct implementation of changes to the second prototype, the same five NEE trainers and three ARC participants were asked to locate materials, write down their location, indicate their search preference, and provide feedback on their UX. In the two usability testing sessions, the correctness of the location of the materials was verified.

The Dissertation Format

The three-article dissertation format was selected because the creation and dissemination of the practical knowledge differ from platform to platform due to different technological capabilities, the purpose and functions behind individual online CoPs, and the varied, or the lack of, knowledge curation practices in online CoPs. The series of studies allows for a better understanding of the creation and dissemination of practical

knowledge under different asynchronous online environments with increasing functions of knowledge distribution, collaboration, and topic categorization. In study #1, the codification of practical knowledge occurs between IDT practitioners and community leaders in the form of online articles. These online articles are disseminated through a CMS platform as the essential aspect of resource distribution in ICTs. In study #2, the codification of practical knowledge occurs among IDT practitioners who willingly participate in online CoPs on Facebook. Facebook groups provide a mechanism for collectively distributing resources and collaborative features to share practical knowledge while integrating topic categorization through hashtags. While the codification of practical knowledge occurs in online CoPs in the first two studies, NLP methods are suited for better understanding how online CoPs build and share practical knowledge under two web technology configurations (i.e., CMS and Facebook platforms) by examining the large-scale codified knowledge of actual users on these platforms as an authentic representation of how community members interact with others in their respective technology platforms. In study #3, usability testing guided the development of efficient user interfaces to support the organization of codified practical knowledge in the form of asynchronous online instructional modules based on Missouri teacher standards that assist educators in various roles. This dissertation format builds the foundation of my research agenda and future studies of online CoPs.

The remainder of this dissertation is organized as follows. Chapter 2 provides an overview of the three studies, including the study goal, theoretical background, methods, main results, implications, conclusion, and ethical considerations. Chapter 3 concludes the dissertation with a discussion, implications on research and practice, recommended

design features and implementation examples, limitations, key findings of individual studies, concluding remarks, and future directions.

Chapter 2: Overview of the Three Studies

The sequence of studies presented in the dissertation represents the critical step for improving IDT CoPs by analyzing the accumulated practical knowledge through NLP to explore how community members use respective CoPs with CMS and social media platform configurations for knowledge sharing and collaboration purposes. Thus, studies #1 and #2 revealed the purpose, functions, and types of practical knowledge exchanged and led to design recommendations that improve IDT CoPs as conducive information spaces for independent exploration of practical knowledge and alignment to professional competencies and standards in IDT. This dissertation culminates in study #3 as a design case for redeveloping an existing online CoP for teacher professional development to support users' primary information task of locating professional development materials aligned with Missouri teacher standards. The studies in the dissertation are published in open access journals for increased dissemination and visibility of the findings.

I am the sole author of the articles in this dissertation that were accepted in the following scholarly journals:

Study 1: published in *Knowledge* (article #1 in Appendix 1). As part of the Multidisciplinary Digital Publishing Institute (MDPI), this journal was recently established in 2021 and did not have an Impact Factor or alternative journal metrics at the time of the submission (*Knowledge*, n.d.-a). Despite lacking citation metrics, this journal is indexed in several indexing and abstracting services, including CNKI, DOAJ, PATENTSCOPE, and ProQuest (*Knowledge*, n.d.-b). Also, 86% of journals in MDPI have earned their Impact Factor from 2020 (*2021 Impact Factors – Released*, n.d.). As an international double peer-reviewed open access journal, this manuscript aligns with the

aims and scope of the journal by providing full experimentation details in knowledge-related technologies. Citation:

Leung, J. (2022). An NLP Approach for Extracting Practical Knowledge from a CMS-Based Community of Practice in E-Learning. *Knowledge*, *2*(2), 310-336. https://doi.org/10.3390/knowledge2020018

Study 2: published in *IEEE Access* (article #2 in Appendix 2). The Impact Factor of this journal is 3.476 as of 2021. *IEEE ACCESS* uses a double-blind peer-reviewed journal with an acceptance rate of 30% (IEEE Open, 2022). As a multidisciplinary open access and online-only journal, I selected this journal to showcase this original research across multiple disciplines that are freely available to all readers. Citation:

Leung, J. (2022). Examining the Characteristics of Practical Knowledge from Four Public Facebook Communities of Practice in Instructional Design and Technology. *IEEE Access*, *10*, 90669-90689. https://doi.org/10.1109/access.2022.3201893

Study 3: published in the *International Journal of Designs for Learning* (IJDL) (article #3 Appendix 3). Although IDJL does not have an Impact Factor or alternative journal metrics, IDJL is an open access journal sponsored by the *Association for Educational Communications and Technology* (AECT) dedicated to publishing only design cases. IDJL uses a double-blind peer-review process with an acceptance rate of 56%, receives 60 submissions on average, and is accessed by authors and readers in over 130 countries. This manuscript was nominated for the SIG Design and Technology Outstanding Design Case Award at the *American Educational Research Association*

(AERA) in November 2022 (*International Journal of Designs for Learning*, n.d.). Citation:

Leung, J. (2021). Design Features of Online Teacher Professional Development: A Design Case for Re-Developing the EdHub Library to Improve Usability and Alignment of Content with Teacher Standards. *International Journal of Designs for Learning*, *12*(2), 79-92. https://doi.org/10.14434/ijdl.v12i2.29578

The remainder of this chapter summarizes the study goal, theoretical background, methods, main results, implications, conclusion, and ethical considerations.

Study 1: An NLP Approach for Extracting Practical Knowledge from a CMS-Based Community of Practice in E-Learning

Study Goal (Problem Statement)

The first study used CMS technology to examine an online CoP in e-learning development. The CMS technology represented the most basic knowledge production and sharing mechanism. The online CoP relied on membership and publishing sharing capabilities to distribute online articles related to IDT practice. The CMS platform provided critical mechanisms for knowledge exchange and collaboration between community leaders and IDT practitioners. While this online CoP used the seven news categories to organize the production of online articles, additional structures within news categories and cross-referencing produced articles across news categories are needed to facilitate knowledge and skills development. Although customizable IAs characterize CMS platforms, knowledge production through member interactions in the user

comments section is underutilized because of the distributed management of hundreds of static HTML pages (e.g., online articles) and the lack of monitoring of user comments at the administrative level that leads to the inconsistent knowledge creation and advancement of skills in IDT.

Theoretical Background

The study adopted the SECI model by Nonaka and Takeuchi (1995). According to the SECI model, knowledge is created through continuous socialization, externalization, combination, and internalization processes. At the externalization stage, the practical knowledge of IDT practitioners is codified into online articles related to practitioners' professional experiences with pedagogical and technological aspects of IDT practice. In the knowledge management literature, NLP is widely used to extract practical knowledge from codified knowledge from e-mail communication and documents. Through various NLP tasks used in the study, practical knowledge was explored to understand the knowledge creation capabilities, characteristics, and priorities of the e-learning development CoP.

Methods

NLP tasks were implemented to analyze 9,003 online articles for each of the seven news categories, including *Learning Management System* (927), *E-Learning Software* (400), *E-Learning Trends* (2,934), *Design and Development* (2,415), *Instructional Design* (1,065), *Best Practices* (972), and *Free Resources* (320). Online articles were identified based on the sitemap to avoid duplicating articles within and across news categories. First, lambda functions determined the average word and

sentence lengths better to understand the general syntactic characteristics of online articles. After using a stop words dictionary, word frequencies and trigrams were generated to explore essential words and their probabilities of appearing together. Second, sentiment analysis and entity recognition and their relationships were also explored in online articles. The sentiment analysis of online articles allowed for identifying articles written in positive, neutral, and negative tones. The entity recognition and relationships aspect identified the pedagogical and educational technology concepts used in the online CoP. Third, topic modeling algorithms (i.e., LDA and BERTopic) were used to identify the emerging subthemes in individual news categories. Topic modeling allowed for understanding the topic characteristics from online articles in a given news category.

Main Results

Results show that the e-learning CoP prioritized writing online articles related to educational technology, particularly LMS platforms, as a critical component for managing and delivering e-learning courses to students or employees for onboarding, skill development, and compliance reasons. The majority of the online articles were written with a positive tone. Also, most recognized entities were educational technology-related but with a few pedagogical concepts. The online articles in the LMS news category were the longest, with an average word count of 1,214.7 words, indicating that the community prioritized the development of such articles in that news category. While the online articles produced in this online CoP were in the form of recommendations, evaluations, and reports, the e-learning development CoP tended to reference other materials within the online CoP and external resources such as blog posts, research

articles, and educational technology vendors. Based on the findings, the topic models across the news categories emphasized e-learning materials production with LMS platforms and e-learning authoring tools.

Implications

Although this online CoP emphasized the educational technology aspect of IDT practice in their online articles, the study has implications related to the lack of community standards for evaluating produced articles written by IDT practitioners and the lack of pedagogical foundations that support the implementation of educational technology. While the seven news categories are used for the general organization of topics, the study made recommendations for cross-referencing educational technology-related articles within the instructional design news categories, adhering to professional competencies in IDT to monitor the production of articles, creating additional learning opportunities in the learning sciences, and increasing the online CoP's transparency of how online articles are produced.

Conclusion

The practical knowledge extracted from the e-learning development CoP using a CMS platform showed that the current IA is insufficient to organize the technical and cognitive aspects of practical knowledge in IDT. The results of this study can be used to enhance individual news categories further. Future research was suggested to further investigate the emerging topic patterns by sentiment to uncover the challenging aspect of IDT and develop taxonomies that classify technical and cognitive tacit knowledge.

Study 2: Examining the Characteristics of Practical Knowledge from Four Public Facebook Communities of Practice in Instructional Design and Technology

Study Goal (Problem Statement)

The second study examined four IDT CoPs on the Facebook platform, where community members not only produce but can also share practical knowledge and collaborate on specific issues related to IDT practice. The Facebook platform is better suited for knowledge creation and sharing asynchronously through a chronological news feed with embedded search and document-sharing functions in Facebook groups. Although Facebook groups differ from a CMS's capability for creating custom IAs, community members rely on the hashtag structure developed by administrators and members to distribute and organize user posts in topic categories. However, the hashtags structures currently used in IDT CoPs do not represent the accumulated practical knowledge and provide little value to knowledge discovery and reusability efforts.

Theoretical Background

Similar to the first study, the study adopted the SECI model, where knowledge is created through a continuous process of socialization, externalization, combination, and internalization (Nonaka & Takeuchi, 1995). In this study, community members exchange practical knowledge through socialization and externalization processes in IDT CoPs on the Facebook platform and integrate newly encountered practical knowledge into their own IDT practice. The practical knowledge that was externalized or codified in the news feed of IDT CoPs can be extracted and analyzed with NLP to explore further members' interactions and the types of practical knowledge. Although IDT CoPs on Facebook

relied on hashtag structures to organize user posts, NLP tasks implemented in the second study showed the purpose, functions, emerging topic patterns from the accumulated practical knowledge, and the frequencies of exchange of practical knowledge.

Methods

Following similar methods from the first study, a total of 7,713 user posts from four IDT CoPs from September 2017 to September 2020 were analyzed individually with NLP tasks, including *Instructional Designer* (6,000), *Designers for Learning* (348), *Adobe Captivate Users* (641), and *Articulate Storyline* (724). The aforementioned online CoPs had the largest membership count and were open to outside members of the Facebook platform. The number of posts was reduced to 6,066 posts by removing posts with no context (e.g., *hi*, *hi there*, *hello all*, and *good morning professionals*) and posts with promotional links and multimedia assets. Once user posts were cleaned, lambda functions were performed to determine the syntactic characteristics to understand the posts' average word and sentence lengths. After removing the uninformative words using a stop words dictionary, word frequencies and four-grams were generated to explore relevant words and their probabilities. User posts also underwent two NLP tasks to determine posts' sentiment stances (i.e., positive, neutral, and negative) and identify pedagogical and educational technology entities and their relationships in each Facebook group. The last NLP task was related to topic modeling to discover hidden semantic characteristics or meaning behind posts using topic modeling with LDA and BERTopic in individual IDT CoP.

Main Results

The results of this study showed general, unique, and shared characteristics among IDT CoPs. As a general characteristic shared among IDT CoPs, members used four sentences or less to seek pedagogical and technical advice. Despite the different number of posts in the *Instructional Designer* and *Designers for Learning* CoPs, these two CoPs showed similar sentiment distributions from 70%-72% for positive sentiment, 22% for neutral sentiment, and 6%-8% for negative sentiment. In addition, the *Adobe Captivate Users* and *Articulate Storyline* CoPs showed similar sentiment distributions of 56%-60% for positive sentiment, 28%-29% for neutral sentiment, and 12%-15% for negative sentiment.

Although pedagogical entities were less prevalent than educational technology entities, results showed an active exchange among members by giving thanks and referring members to additional resources. In addition, online CoPs had different conventions for distributing resources. It is worth noting that the *Instructional Designer* CoP was prone to the discussion of learning misconceptions due to the lack of community protocols. Also, hashtags in the *Instructional Designer* CoP were utilized heavily for distributing resources for e-learning development and LMS integration. The *Designers for Learning* CoP relied less on hashtag structures to discuss topics related to learner engagement strategies, gamified learning, and free professional development opportunities. Even though members in the *Adobe Captivate Users* and *Articulate Storyline* CoPs were used for solving issues with their respective e-learning authoring software, the results showed different conventions for greeting others and distributing resources. For instance, new members in the *Adobe Captivate Users* CoP are introduced

to others before asking for advice. Members of the *Articulate Storyline* CoP relied heavily on video tutorials posted by administrators that contained misspellings.

Based on the topic structures, the unique characteristics of the *Instructional Designer* CoP were related to asking peers to review instructional design portfolios and the solicitation of resources for educational animation. The unique characteristics of the *Designers for Learning* CoP were associated with the development of serious games for learning, online game development, and educational technology tools. The shared characteristics between the *Instructional Designer* and *Designers for Learning* CoPs were related to inquiries about graduate programs in instructional design, job postings, event announcements, and general resources for course development. Regarding the e-learning development CoPs, the unique characteristics of the *Adobe Captivate Users* CoP were related to mobile development, e-learning course integration with LMS platforms, and general e-learning development workflows. In contrast, the unique characteristic of the *Articulate Storyline* CoP was the integration of JavaScript with the e-learning software.

Implications

Given the characteristics of practical knowledge in the study, the four IDT CoPs lacked knowledge discovery mechanisms for allowing members to find solutions on their own and provided no mechanisms for aligning practical knowledge with established professional benchmarks of the profession. It is important to note that the hashtag structures used in these IDT CoPs are not representative of the accumulated practical knowledge and are not conducive to knowledge discoverability and reusability. The topic structures found in this study can be implemented to curate practical knowledge to enhance IDT CoPs with knowledge management practices. While online CoPs can reach

new members worldwide, IDT CoPs need to take foundational steps by curating their practical knowledge through topic structures from this study and providing clear statements about the purpose of the community, types of practical knowledge, community protocols for addressing learning misconceptions, and onboarding new members. IDT CoPs also are not conducive spaces for providing pedagogical foundations to practitioners. Although IDT CoPs played a critical role during the COVID-19 pandemic as practitioners transitioned from face-to-face to hybrid and emergency remote teaching (ERT), this study suggested that IDT CoPs include pedagogical resources in the form of information hubs or pandemic response pages to support educational technology selection and implementation.

Conclusion

The practical knowledge extracted from the four online CoPs of interest using the Facebook social media platform showed several shortcomings as efficient information spaces. The IDT CoPs under investigation lacked effective mechanisms for organizing the accumulated practical knowledge, onboarding new members, correcting learning misconceptions, and supporting IDT practitioners with pedagogical foundations. Future research was suggested to investigate user posts by sentiment to explore the challenging aspect of IDT practice, examine the priorities and evolution of topics in online CoPs, create a comprehensive entity dictionary for investigating similar online CoPs, and develop API interfaces to aid the knowledge discovery and reusability of practical knowledge for the whole community.

Study 3: Design Features of Online Teacher Professional Development: A Design Case for Re-Developing the EdHub Library to Improve Usability and Alignment of Content with Teacher Standards

Study Goal (Problem Statement)

The third study described a design case for designing a user interface that supported different types of educator roles (e.g., principals, teachers, and instructional staff) and their level of experience with teacher professional development. Technical and usability issues in the first generation of the teacher professional development platform, the EdHub Library, prompted discussions for resolving issues related to privacy and sharing settings over teacher journals, navigation issues, and maintenance of the platform within the University of Missouri. This study was guided by five design decisions that met the goals of internal stakeholders, developers of teacher professional development, and school districts. These five design decisions include:

1. Prioritizing visual elements
2. Ease of navigation across all levels of the library
3. Searching materials with sitemaps across multiple and individual teacher standards
4. Utilizing a search engine that organizes search results by topic category
5. Creating a single point of access to all materials

Furthermore, two usability testing sessions performed with NEE trainers emulated experienced educators who looked for professional development materials based on Missouri teacher standards through teacher indicator sitemaps. Also, participants from ARC acted as beginning teachers and instructional staff who were not experienced with

teacher professional development. They relied on the home directory and search engine to observe all available material in the EdHub Library.

Theoretical Background

The five design decisions were guided by a literature review of teachers' information-seeking behaviors and Nielsen's (1994) heuristics for user-interface design. Limberg (1999) argued that teachers had three significant information-seeking habits, including fact-finding, choosing the correct information, and evaluating the information. Limberg and Sundin (2006) discovered teachers' information-seeking approaches in searching subject-specific as user-oriented tasks and general information applicable to several contexts and applications in the classroom as context-dependent tasks. Shipman (2015) also discovered that teachers seek the practical aspects of teaching in the form of instructional design of lesson plans, classroom exercises, assessment tools, and action research topics. Furthermore, Nielsen (1994) stated the ten principles for interaction design, including visibility of system status, match between the system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover from errors, and help and documentation. These principles were used to analyze the current challenges in the first generation of EdHub and design prototypes that supported the platform's redesign.

Additional information sources assisted with understanding educators' needs and challenges when using the first generation of the EdHub Library, including a survey, informal feedback from principals, and a prior study on educators' resource utilization patterns (Leung, 2018). Survey results showed the technical and usability challenges

when educators accessed the first generation of the platform. Leung (2018) discovered that educators accessed teacher professional development through the existing data collection tool provided by NEE, and activities located in deeper levels of the library had little to no pageviews. This user preference indicated that educators searched for professional development materials once they identified areas of improvement from the data in reporting tools. External logins to the CMS in the first generation were also deemed challenging after analyzing the teacher reports.

Methods

The platform prototype was refined through two usability testing sessions through voluntary participation from NEE and ARC staff within the University of Missouri College of Education and Human Development. Five NEE trainers acted as expert educators in teacher professional development, whereas three ARC staff emulated educators as beginning teachers and instructional staff with little experience with teacher professional development. No identifiable information was collected from the eight participants to ensure the anonymity of responses. The third study was conducted as part of my duties as an instructional designer for departmental purposes to improve existing university-related services to school districts part of NEE. This particular study was divided into four phases over 11 months. In the first phase, the purpose of initial meetings required the identification of the current challenges in the first generation of the platform, necessary elements in the new version of the platform, technology requirements, migration planning, and communication planning of the transition. I was responsible for the prototype development and usability testing sessions in the second phase. The final prototype was deployed in the third phase after incorporating the feedback from the two

usability testing sessions. In the final phase, the first generation of the platform was discontinued.

The first prototype contained three main homepage sections: getting started, search engine feature, and topic categories. In the first usability testing session, five NEE trainers were tasked with looking for specific professional development materials, writing down the location of the materials, and providing feedback related to their UX. Based on the first usability testing session, a second prototype was developed to incorporate teacher indicator sitemaps on the homepage as the fourth element. The same five NEE trainers from the first usability testing session and three ARC staff were given a new task: look for new professional development materials, write down their location, provide feedback related to their experience, and indicate their search preference. The search preference for materials included the homepage with topics, search engine, or teacher indicators sitemaps. In the two usability testing sessions, I verified the correctness of the materials.

It is worth noting that the goal of usability testing sessions was to test the effectiveness of the prototypes against the information tasks given to participants. In the final publication, however, I referenced usability testing as user testing that provided the wrong message of testing users against the prototypes instead of testing the effectiveness of prototypes through information tasks.

Main Results

The results from the first usability testing session with NEE trainers revealed improvements to the user interface and functions of the search engine. These changes included the addition of social media bookmarks on the homepage and teacher indicator

sitemaps, eliminating unnecessary components (e.g., news and curated content bookmarks), removing search functions at the topic and module levels, reducing the size of the EdHub logo from the homepage, and organizing search results to mirror the topic organizational scheme of the EdHub homepage. The second usability testing session showed that the improved prototype allowed NEE trainers to locate professional development materials more efficiently in under 20 minutes. In contrast, ARC staff took around 30-40 minutes to look for materials from the homepage and search engine.

Implications

The redesign of the EdHub Library has implications for designers and developers of CMS platforms, providers of teacher professional development, and standards-based professional development. First, platform designers can understand Plone's current challenges with platforms that support professional development; an open-source CMS utilized in the first generation of the platform. While CMS platforms are necessary for controlling membership and access to materials, developers of platforms should identify the technical needs and challenges that school educators face when accessing multiple tools with several login credentials. Second, teacher professional development providers can understand the technical and administrative requirements and benefits for maintaining professional development within the organization. Third, the interface redesign supports new and experienced educators in standards-based professional development through three search mechanisms and consistent presentation of materials that allow for alignment to Missouri teacher standards. Also, the redesigned interface accommodates educators' abilities to search materials based on their information goals.

At the same time, search mechanisms and consistent presentation of information aid educators' information goals.

Conclusion

The practical knowledge presented in standard-based professional development can be organized to consistently provide users with the alignment of professional development resources with Missouri teacher standards. The study showcased how to support educators' user-oriented and context-dependent information tasks. The redesign of the EdHub Library improved navigation and usability, ensured user privacy, and enabled designers with in-house maintenance.

Ethical Considerations

Three ethical considerations involved accessing publicly available information, protecting the anonymity of users, and protecting the organizational knowledge capital of online CoPs. In the first study of the CMS-based e-learning CoP, online articles were publicly available without login credentials that allowed web scraping tasks. In the second study of IDT Facebook groups, user posts from the four IDT CoPs were open or public, meaning that users can view user posts without a Facebook login credential. In the third online teacher professional development study, the participants who volunteered in the usability testing sessions were staff within a university setting, and their feedback was anonymous. The third study also required no approval procedures or declaration to the Institutional Review Board (IRB) at the time when the study was conducted because the activities were designed for quality improvement of an existing program, which was part of the teacher professional development in one of the outreach units in the College of Education and Human Development at the University of Missouri. Although scraping

techniques were used to obtain the data sources for the first two studies, authorship information was deleted to prevent the identification of authors and users in their respective online CoPs. While the first two studies relied on NLP to analyze large amounts of textual data from the public domain, individual studies' data sources are unavailable to protect their organizational knowledge and prevent potential disruptions in member participation.

Despite the general rule of informed consent for research involving human subjects, informed consent in large-scale online environments poses logistical challenges and compromises the validity of research results. The concern of asking for informed consent in large-scale online environments involves the need for practicality in collecting informed consent from thousands of participants. Receiving acknowledgment of informed consent is also challenging, where community participation varies significantly. Although Rebers et al. (2016) argue that asking for informed consent from community leaders is an acceptable alternative, informed consent introduces participation bias (i.e., Hawthorne effect) at the online CoP's member and leader levels that lead to inaccurate research findings by altering participants' behaviors when sharing and monitoring practical knowledge. In light of the absence of informed consent, the studies involved minimal research risks to participants by not collecting their information to preserve their privacy, confidentiality, and anonymity that could not be traced back to participants. Williams et al. (2017) argue that not providing informed consent can be justified to ensure the validity of research results while avoiding the disinhibiting effect of participation bias in large-scale online environments. However, future research should involve software vendors and leaders of online CoPs to find alternative means to obtain

informed consent from users in large-scale online environments as part of continuous improvement and research efforts to improve platforms that host online CoPs. The potential partnerships amongst software vendors, researchers, and leaders of online CoPs can lead to mitigating the effects of participation bias.

Chapter 3: Discussion and Conclusion

In this three-article dissertation, I explored online CoPs in IDT and teacher professional development using ICTs, including CMS, social media, and custom web development. Asynchronous online platforms enable community members' production and exchange of practical knowledge. This dissertation contributes to the field of IDT, teacher education, and software development in several ways:

1. Examine the practical knowledge produced and exchanged in platforms by analyzing the rich organizational knowledge capital in online CoPs.
2. Provide a better understanding of different platforms' purposes, functions, and knowledge exchange characteristics.
3. Highlight the need for online CoPs to effectively curate knowledge through better topic structures aligned with professional standards within the current capabilities of platforms.
4. Give providers of professional development, software developers, and professional organizations an understanding of how community members exchange knowledge in online CoPs.

The first study analyzed the syntactic and semantic characteristics of codified knowledge found in online articles produced by IDT practitioners organized in seven e-learning news categories using WordPress as a blog-publishing platform. A blog-publishing platform relies on CMS technology to manage the creation and modification of digital content and its users. A few features of this CMS include the ease of administration of pages and users, customizable content templates, and minimal server requirements. The results of the first study showed that the e-learning news outlet CoP

placed a heavy emphasis on producing articles related to the technical aspects of e-learning materials production. The first study noted that the pedagogical aspects of e-learning development were present to a lesser degree. This first study highlights the need to (a) develop online articles related to the pedagogical foundations of IDT, (b) verify the quality of knowledge produced, (c) cross-reference content across news categories, and (d) align online articles with professional standards.

The second study investigated the codified knowledge from users' posts in four public Facebook groups in IDT to further understand how community members exchange practical knowledge and the various functions of individual online CoPs. The CoPs in IDT are public or open on the Facebook social media platform meaning anyone can review user posts without participation. Anyone with a Facebook profile can join public Facebook groups to participate in discussions, events, and document sharing. As one of the most convenient online platforms to launch online groups, the Facebook social media platform allows community administrators and members to create their set of hashtags to organize content in topic categories. Community members can pin specific hashtags deemed necessary for others to discover. However, the second study's findings showed that hashtags in online CoPs were used ineffectively and did not reflect the accumulated practical knowledge as the organizational capital of online CoPs. The results of the second study showed the purposes and unique and shared characteristics of four IDT Facebook groups. The second study showed that educational technology advice was more prominent than pedagogical advice in the four Facebook groups and lacked effective mechanisms to organize their practical knowledge. Additionally, two common characteristics among the online CoPs under investigation were the lack of information

for onboarding new members and protocols for addressing misconceptions in IDT practice. The second study provides recommendations for community leaders to better organize their organizational knowledge capital, allowing members to look for specific solutions independently with a higher specificity related to the IDT practice.

The third study aimed to develop an information space, the EdHub Library, that supports educators with user-oriented and context-dependent tasks when aligning professional development materials with Missouri teacher standards. The third study provided this CoP with an improvement of a three-level or hierarchical tree structure through custom web development. The primary motivation for redesigning the EdHub Library was to address critical technical and usability issues in the first generation of the platform built on an open-source CMS called Plone. The technical challenges of the first generation of the library revolved around the lack of privacy and sharing options over teacher journals and visibility of content to other school districts. The usability challenges of the first generation of EdHub were related to the cumbersome navigation structures and the need for more alignment of professional development materials with Missouri teacher standards. Although the third study mainly used two usability testing sessions of two prototypes with NEE trainers and ARC members, additional information and feedback guided the second generation of EdHub, including a teacher survey, informal feedback from school administrators during training sessions, a literature review of teachers' information-seeking behaviors, and a study of resource utilization patterns of the first iteration of the platform (Leung, 2018). The final implementation of the second generation of EdHub took 11 months to complete and was launched in the Summer of 2018. The third study was conducted in four phases to analyze the requirements of the

new platform, design and test prototypes, deploy the platform within the existing classroom observation data tool, and phase out the first generation of the platform. The third study showcases how an information space enables school administrators, teachers, and instructional staff to search for materials in three ways through the homepage directory, search engine, and teacher indicator sitemaps based on the user's level of experience with professional development. The three mechanisms for searching materials support user-oriented and context-dependent tasks. In user-oriented tasks, educators search for materials specific to their information needs, generally new teachers, principals, and instructional staff. New teachers perform user-oriented tasks to find the most critical pieces of professional development to improve their classroom management skills. Principals seek simulation resources to practice scoring teachers in the classroom. Instructional staff look for specific resources that support teachers (e.g., instructional and technology coaching) and students (e.g., Dyslexia and accessibility coaching). In context-dependent tasks, educators, mainly experienced teachers, look for materials aligned with Missouri teacher standards across multiple topics using the teacher standard sitemaps and subject-specific materials from the EdHub homepage and search engine.

Discussion

Research Question 1: What design features in online information spaces enhance the exchange of skills and knowledge among members of a community of practice?

Due to the popularity of ICTs, the growth of practical knowledge in IDT CoPs has gone unchecked without the proper assessment of IDT practitioners' professional needs, which led to the over-production of educational technology-related practical knowledge. Although practical knowledge in online CoPs has grown organically due to member

interactions over time, the lack of knowledge management practices has led to the reusability barriers that prevent community members from leveraging the accumulated practical knowledge, especially those members who participate at the periphery (i.e., lurkers) and seek solutions independently without fully engaging with other members. Current research examines the design considerations for creating online CoPs for teacher professional development that are conducive to the professional development of educators and compliance with state teaching standards (Dille & Røkenes, 2021; Macià & García, 2016; O'Dowd & Dooly, 2022). Also, IDT CoPs are not currently configured as efficient information spaces that enable IDT professionals to self-assess their professional development needs against the standards and competencies of the profession.

The studies in this dissertation explored the syntactic and semantic features of the organizational knowledge capital of several online CoPs in IDT. The studies also took inventory of the practical knowledge produced and exchanged using different web technology configurations. In the third study, three mechanisms for locating professional development materials and aligning with Missouri teacher standards can be implemented in other online CoPs to provide consistent topic structures and alignment to any given professional competencies. Online CoPs can become conducive information spaces by enabling members to self-assess existing practical knowledge through topic structures that ensure the reusability of the accumulated practical knowledge. Online CoPs can become information spaces where community members can (a) locate information independently from the accumulated practical knowledge in CMS and social media platforms, (b) increase their ability to self-assess newly encountered practical knowledge

through the alignment of professional competencies, and (c) leverage efficient topic structures for better navigation of the accumulated practical knowledge, and not merely for the distribution of resources.

Implications for Research

The research implications for this three-article dissertation offer opportunities for fellow scholars to examine the mechanisms for sustaining community members' exchange of practical knowledge in the knowledge creation processes, especially when converting practical or tacit knowledge to explicit forms in asynchronous online environments (Nonaka & Takeuchi, 1995). While practical knowledge in online CoPs is continuously created through socialization, externalization, combination, and internalization processes, Nonaka and Takeuchi also argued that the knowledge creation processes occur in four contexts. Based on the SECI model, these four contexts (i.e., *ba* or *basho*) are defined as spaces where community members regularly interact in physical, online, or mental shared spaces and support each stage of the knowledge creation process (Nonaka & Takeuchi, 1995). As the vital element for knowledge sharing, ICTs support online CoPs in several contexts in terms of processes of socialization (originating *ba*), externalization (conversing *ba*), combination (cyber *ba*), and internalization (exercising *ba*). However, the current online CoPs under investigation have shortcomings in supporting community members' exchange of practical knowledge and their respective contexts.

First, the findings of this three-article dissertation suggested that online CoPs need to provide better support for the socialization process when community members deeply exchange practical knowledge (originating *ba*). For instance, IDT CoPs (studies #1 and

#2) lacked the context of originating *ba* where the purpose and functions of the online CoP were not articulated for the benefit of new members. Also, in the context of the teacher professional development CoP (study #3), the socialization context was present. However, it could not be directly observed due to educators' choices to pursue professional development individually or as a group (e.g., professional learning communities or PLCs) in school districts.

Second, findings suggested that online CoPs (studies #1 and #2) that relied on the blog and social media platforms enabled the conversing *ba* context to codify IDT practitioners' practical knowledge of e-learning materials production. However, individual IDT CoPs gave little attention to evaluating produced online articles (study #1) and lacked mechanisms to correct misinformation (study #2). Regarding the third study, the conversing *ba* could not be observed when educators used journal templates to document their learning using professional development resources due to the private nature of teacher journals.

Third, findings showed that the cyber *ba* context was absent in the e-learning news outlet CoP (study #1) when producing and evaluating online articles. However, this particular context was supported through webinars offered through this CoP. Although synchronous communication tools were not studied in IDT CoPs (study #2), community members relied on hashtags to share practical knowledge. However, these hashtag structures did not represent the accumulated practical knowledge based on the topic models. Even though the cyber *ba* could not be observed in the teacher professional development CoP (study #3), NEE trainers often offer classroom observation support to school districts using synchronous communication tools like Zoom. Also, schools have

different ways of bringing teachers together in a synchronous manner to debrief professional development efforts at the school district level. Although the exercising *ba* context could not directly be observed in the individual studies, the internalization of practical knowledge in the fourth context varied greatly from individual to individual. In studies #1 and #2, the exercising *ba* can be examined by surveying or observing practitioners as they integrate newly encountered knowledge and its subsequent integration into their own IDT practice. In study #3, the exercising *ba* can also be studied through document analysis of reflective journals where teachers are asked about implementing instructional strategies and improving their teaching practice.

Implications for Practice

Although the strengths of platforms built on Web 2.0 technologies involve the ease of formation of online CoPs and members' ability to share practical knowledge with others, the current state of technologies presents members with challenges related to the lack of (a) discoverability (b) reusability, and (c) proper representation of the accumulated practical exchanged on these platforms. Greene et al. (2000) suggested that information can be represented as entities that can be visualized in a graphical or textual manner through overviews and previews. Overviews are representations that provide summary depictions of knowledge, whereas previews are representations of knowledge. A typical example of an overview is a table of contents encapsulating all material components. In terms of online CoPs, the generated topic structures found in studies #1 and #2 can be implemented as a table of contents to represent the wealth of practical knowledge better. An example of a preview is an abstract that summarizes the overall contents of written materials. Previews can also be implemented as explicit statements

that encapsulate online CoPs' purpose, knowledge exchange protocols, and mechanisms for onboarding new members.

More specifically, the BoW topics identified in studies #1 and #2 represent the patterns of the accumulated practical knowledge that describe the functions and types of entities (i.e., pedagogical and educational technology) available in individual IDT CoPs. Two types of IA can be implemented to provide better overviews of the accumulated practical knowledge and types of entities available in online CoPs. For example, the first IA focuses on the organization, structuring, and labeling of practical knowledge and entities that represent the purpose and functions of online CoPs from a content-based perspective. The second IA can leverage professional benchmarks in IDT to organize practical knowledge from a professional context perspective. These two IAs can work in tandem to allow community members to manipulate the practical knowledge from content- and context-based perspectives that provide a nuanced view of the practical knowledge in online CoPs.

In the context of this three-article dissertation, CMS platforms (study #1) can provide better overviews of practical knowledge by enhancing the existing IA of individual news categories alongside a second IA that organizes materials by professional standards. In social media platforms (study #2), overviews can be implemented through dashboards using NLP pipelines to digest textual sources that provide a high-level representation of the accumulated practical knowledge. While overviews are intended to provide a high-level summary of online CoPs, previews are designed to summarize practical knowledge. In the first study, CMS platforms can provide valuable content previews through NLP summarization techniques (i.e., extractive and abstractive). In

extractive summarization, summarized user content is extracted by obtaining the most representative words from the original text. In contrast, text summaries are generated from the original user content in abstractive summarization. In the second study using the Facebook social media platform, previews can also be implemented as explicit statements that describe the specific functions, community protocols, onboarding new members in IDT CoPs, and summarization previews of exchanged practical knowledge over time.

Recommended Design Features

Although ICTs play a critical role in the exchange of practical knowledge without geographical and time boundaries, five design features are necessary to enhance community members' ability to browse the accumulated practical as information spaces by enhancing the self-directness of learning (Garrison, 1997) and usability from technological, social, and pedagogical dimensions (Janke et al., 2020). IDT CoPs lacked mechanisms to support cognitive, or self-monitoring, and contextual or self-management processes that allow community members to (a) evaluate the new information encountered as part of the socialization context, (b) share practical knowledge effectively align within the topic representations of the accumulated practical knowledge during externalization and combination processes, and (c) enable IDT practitioners with mechanisms to evaluate practical knowledge against their practice and IDT competencies during their internalization process.

The current state of online CoPs in IDT does not currently support the self-directed learning of community members when browsing practical knowledge and aligning with professional benchmarks in IDT. The design features can support the community member's ability to self-manage by controlling the CoP environment based

on professional development goals and needs by integrating topic representations through effective hashtags structures (i.e., the contextual aspect of manipulating the wealth of practical knowledge) while allowing better internalization of practical knowledge against professional competencies (i.e., the cognitive aspect of evaluating professional knowledge against practitioners' practices). Although usability and UX research has focused on evaluating the learner experience (LX) from a technological standpoint, the social and pedagogical dimensions of UX and LX are often neglected when designing technology-enhanced environments. This disconnect among these three dimensions leads to technology abandonment due to technical issues, insufficient affordances that meet users' needs, and low technology adoption due to unanticipated user needs.

Furthermore, IDT CoPs lacked social presence (i.e., social dimension) and logical organization of the accumulated practical knowledge (i.e., pedagogical usability) when collaborating in an asynchronous online environment. Online CoPs in IDT (study #1 and #2) also act as non-formal learning environments where community members interact with each other to fulfill professional goals and workplace needs. However, UX improvements are required in CMS and social media platforms that allow for meaningful learning experiences from the social, technological, and pedagogical dimensions. As a design case, the teacher professional development CoP (study #3) focused on the three dimensions by improving the arrangement of the user interface (UI) components of materials aligned with Missouri teacher standards (i.e., pedagogical dimension), allowing the attainment of professional goals either individually or collaboratively in PLCs (i.e., social dimension), and organizing materials and representation of search results in a consistent manner (i.e., technological dimension).

Regardless of web technology platforms or the adoption of future development of web technologies, the below design features can be implemented in current platforms to stimulate the self-directed learning and usability dimensions in online CoPs. Table 2 summarizes how the recommended design features support the knowledge creation process, self-directed learning contexts, and usability dimensions. While the first three design features can be integrated into online CoPs, the last two design features rely on the future development of web technologies that allow for processing textual sources.

Design Feature #1: Provide better organizational schemes for categorizing and curating practical knowledge while aligning to professional standards.

While most articles were related to e-learning materials production in the first study, the news categories used in the online CoP required additional topic structures to add a layer to content categorization. Although pedagogical-related online articles were less prevalent than educational technology topics, an additional IA related to professional standards in IDT is required to evaluate better the knowledge production capabilities of this particular online CoP. In the second study of IDT CoPs on Facebook, the hashtag structures used in individual CoPs were used to distribute materials in user posts without any indication of specific topic categories. In the third study of the teacher professional development CoP, the first design feature is implemented in the EdHub Library by organizing teacher materials in three ways: topic categories, teacher indicator sitemaps, and search functions while providing consistent alignment to Missouri teacher standards.

The first design feature has the most significant benefit in three contexts of the SECI model, including the conversing *ba* (externalization), cyber *ba* (combination), and exercising *ba* (internalization) (Nonaka & Takeuchi, 1995). In addition, topic structures

benefit the CoP as a whole by promoting self-monitoring and self-management at the member and CoP levels. Topic structures also support the pedagogical dimension by indicating the characteristics of the accumulated practical knowledge in individual CoPs. While this design feature can be integrated, online CoPs in IDT will need time to re-organize and curate additional e-learning news categories and hashtag structures based on the findings of the first two studies.

Design Feature #2: Establish community protocols for addressing misinformation and onboarding new members.

In the e-learning news outlet CoP (study #1) and IDT CoPs on Facebook (study #2), community protocols for examining misinformation in knowledge production were absent. For example, several articles related to learning styles were present in the e-learning CoP, and no corrective measures were provided to evaluate the quality of online articles. In IDT CoPs on Facebook, community members and administrators were inconsistent in addressing learning misconceptions. Furthermore, community instructions needed to be included on interacting with the accumulated practical knowledge and other members. In the teacher professional development CoP (study #3), this design feature is implemented during the storyboarding and content development processes where the subject-matter expert (SME) and the instructional designer align professional development materials with Missouri teacher standards. Additionally, the teacher professional development CoP has specific materials for new members (e.g., beginning teachers and new principals) who need instructions on utilizing the EdHub Library for their respective roles.

By implementing the second design feature, community members are better positioned to interact with others while constructing knowledge collaboratively during the socialization process (i.e., originating *ba*), taking responsibility for the construction of knowledge critically and meaningfully (i.e., self-monitoring), and establishing clear protocols for addressing the validity of knowledge shared in online CoPs (pedagogical dimension). First, leaders of online CoPs need to provide community members with protocols for addressing misinformation and onboarding new members. Without these community protocols, community members inadvertently internalize flawed mental models that lead to inaccurate modification of practitioners' professional knowledge. Also, community members not only acquire practical knowledge by observing others without full participation but also acquire the tacit norms in the online CoP that lead to an inconsistent way to share practical knowledge. Second, this design feature allows community members to self-monitor when internalizing new knowledge into their practice. Also, this design feature allows community members to question the validity of misinformation encountered in online CoPs as they become aware of their construction and internalization of new knowledge. Third, community members interact not only with others and the interface from the social and technological usability perspectives but also with the wealth of accumulated practical knowledge in CoPs from a pedagogical usability perspective. This particular design feature can be implemented as a checklist or statements that foster a collective responsibility when encountering misinformation. This design feature can be easily implemented in online CoPs using CMS and social media platforms. For instance, online CoPs can instruct community members to tag user posts or report online articles that may contain misinformation for later review.

Design Feature #3: Increase transparency in online CoPs by explicitly stating the purpose, functions, and protocols for producing, eliciting, and evaluating practical knowledge.

While the purpose is articulated in the e-learning news outlet CoP and the topic structure provided a scheme for organizing online articles (study #1), it is also essential to articulate (a) the sub-topic categories within the more major news categories, (b) types of online articles (e.g., evaluation reports, whitepapers, pedagogy, and educational technology), and (c) quality criteria for online articles aligned with professional standards. Including these three recommendations give community members a high-level overview of what is available on the site while evaluating content against professional standards. The e-learning news outlet CoP can also adopt professional standards to carefully understand the types of online articles produced by IDT practitioners.

In study #2 of IDT CoPs, the purpose is articulated for the *Instructional Designer* and *Designers for Learning*, but not in the *Adobe Captivate Users* and *Articulate Storyline* Facebook groups. Because of the lack of curation of knowledge practices and effective topic structures in Facebook groups, clear statements about the purpose, functions, and protocols can assist community members with understanding the types of practical knowledge available in online CoPs. Although entity relationships in study #2 showed an active exchange of pedagogical and educational technology advice, online IDT CoPs had no consistent means for eliciting and sharing practical knowledge among community members. For example, community members asked for educational technology options for online training but needed to disclose the contextual factors about the learning environment and learner needs. Community administrators can adopt the

Subjective Objective Assessment Plan (SOAP) technique by Herschel et al. (2001) as a critical community protocol for helping community members with knowledge exchange. The SOAP technique is mainly used in medical settings. However, it can be implemented in online IDT CoPs to articulate the background information needed to understand the problem, state the overall objective of the intervention, assess the best option to close the gap, and create a feasible implementation plan.

Transparency in the teacher professional development CoP (study #3) is aligned with NEE's comprehensive system for educator training and evaluation. Also, SMEs and NEE trainers provide quality control of professional development materials. The EdHub Library in study #3 provides three mechanisms for searching professional development materials aligned with classroom observation rubrics and teacher indicators.

By adding transparency in the form of community protocols, the third design feature enables the socialization aspect of knowledge creation while supporting self-monitoring and self-management in self-directed learning and the social and pedagogical usability dimensions. It allows community leaders to take inventory of the knowledge produced, and members can consistently know what is available. Although this design feature can be implemented in online CoPs, it may be challenging to implement as community norms have been embedded since their inception. A radical shift in how community members exchange practical knowledge may prove challenging to enforce in a non-formal learning space from a community leadership perspective.

Design Feature #4: Improve the search engine functions while aligning with topic structures and competencies.

The search engine tools utilized in the e-learning news outlet CoP (study #1) and IDT CoPs on Facebook (study #2) provided essential functions for searching online articles and user posts within the respective online CoP. However, the search engine tools needed to provide a mechanism for users to sort through the accumulated practical knowledge. Search engine services can be further optimized to organize search results to support the combination stage of the knowledge creation process, where practical knowledge can be organized into meaningful topic structures that allow users to quickly understand specific aspects of IDT practice. The customization of the search engine service also supports users with self-management tasks in self-directed learning and the technological usability dimension that leads to better evaluation of content by reducing users' cognitive load of search results. Study #3 of the teacher professional development CoP is an example of how a search engine tool can be tailored to sort through the wealth of content while organizing results to mirror the topic categories from the EdHub Library homepage and teacher indicators. SiteSearch360 is a search engine service used in study #3 that allowed for the manual curation of instructional modules under topic categories.

To implement the fourth design feature, the e-learning news outlet CoP needs to create topic categories that organize search results based on the general news categories and sub-topic within the more prominent news categories. Although this design feature is feasible for implementation, community leaders in the e-learning news outlet CoP require time to manually tag online articles based on topic, sub-topic, and professional standard categories. In the case of IDT CoPs, the search functions within individual Facebook groups will require an additional time investment to manually organize user posts based on topic categories and professional standards. Additionally, the search function on the

Facebook platform will require NLP pipelines to process user posts and organize them in search results categories that mirror the hashtag structures.

Design Feature #5: Leverage NLP pipelines to process and organize practical knowledge to promote member engagement and knowledge sharing.

While studies #1 and #2 required web scraping methods to process online articles from the e-learning news outlet CoP and user posts in IDT CoPs on the Facebook platform, it is not an ideal scenario to offload and perform NLP tasks to process large amounts of textual data. Online CoPs will significantly benefit from ICTs integration with NLP pipelines that allow for processing textual data, identifying and categorizing entities, and identifying the overall semantic meaning of text sources. The future generation of ICTs can integrate with NLP pipelines using two types of dashboards that track patterns in practical knowledge at the community member and administrator levels.

Although implementing the design feature in online CoP will heavily depend on the evolution of web technologies, the technological aspect of this design feature alone cannot guarantee a high level of utility to community members and administrators. Because NLP pipelines will require a supervised machine learning approach to categorize multiple labels in practical knowledge, online CoPs need to improve their knowledge curation practices by categorizing content based on topic structures found in studies #1 and #2. Once the accumulated practical knowledge is categorized, community member and administrator dashboards can effectively process textual sources that benefit three aspects of the knowledge creation process (i.e., socialization, conversing, exercising contexts), self-monitoring and self-management in self-directed learning, and the three usability contexts (i.e., social, technological, and pedagogical).

Table 2.

Design Features That Support SECI, Self-Directed Learning, and Usability Dimensions

Design Feature	SECI Context	Self-Directed Learning Context	Usability Dimension
1. Topic categorization	Conversing *ba* (externalization) Cyber *ba* (combination) Exercising *ba* (internalization)	Self-monitoring Self-management	Pedagogical
2. Community protocols	Originating *ba* (socialization)	Self-monitoring	Social
3. Community transparency	Originating *ba* (socialization)	Self-monitoring Self-managing	Social Pedagogical
4. Search engine functions	Cyber *ba* (combination)	Self-management	Technological
5. NLP pipelines	Originating *ba* (socialization) Conversing *ba* (externalization) Exercising *ba* (internalization)	Self-monitoring Self-managing	Social Technological Pedagogical

Implementation Examples of Design Features

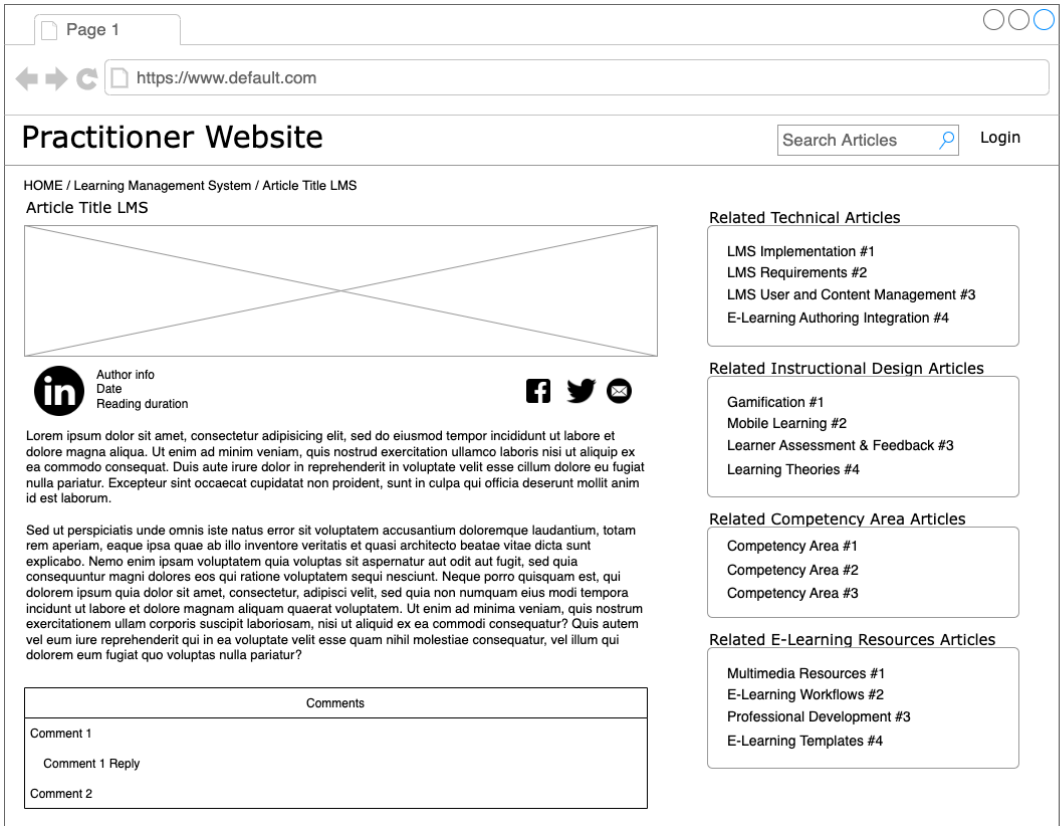
For study #1, the design features can be implemented in the e-learning news outlet CoP. Figure 1 describes the first design feature where online articles are cross-referenced to other articles in different areas of IDT practice. For instance, a technical-related online piece (e.g., LMS) is displayed within the LMS category with supporting pedagogical resources and related IDT competencies. In this manner, the accidental, experienced, or

newly minted IDT practitioners can support their pedagogical foundations related to educational technology.

Although the e-learning news outlet CoP values educational technology-centered over pedagogical-related online articles, this online CoP must provide transparency of how community leaders select the publication of online articles and how online articles support professional competencies in IDT. Community leaders should model their evaluation selection practices of IDT knowledge that allow members to self-assess and advance their professional practice. The future generation of web technologies should enable online CoPs to detect users' sentiments and recognize pedagogical and educational technology entities from the user comments section using NLP pipelines to understand the professional needs of IDT practitioners. At the same time, future web technologies should enable community leaders with a high-level overview of members' responses to online articles to explore the challenging aspects of IDT practice from the practitioner's perspective.

Figure 1.

Wireframe of the E-Learning News Outlet



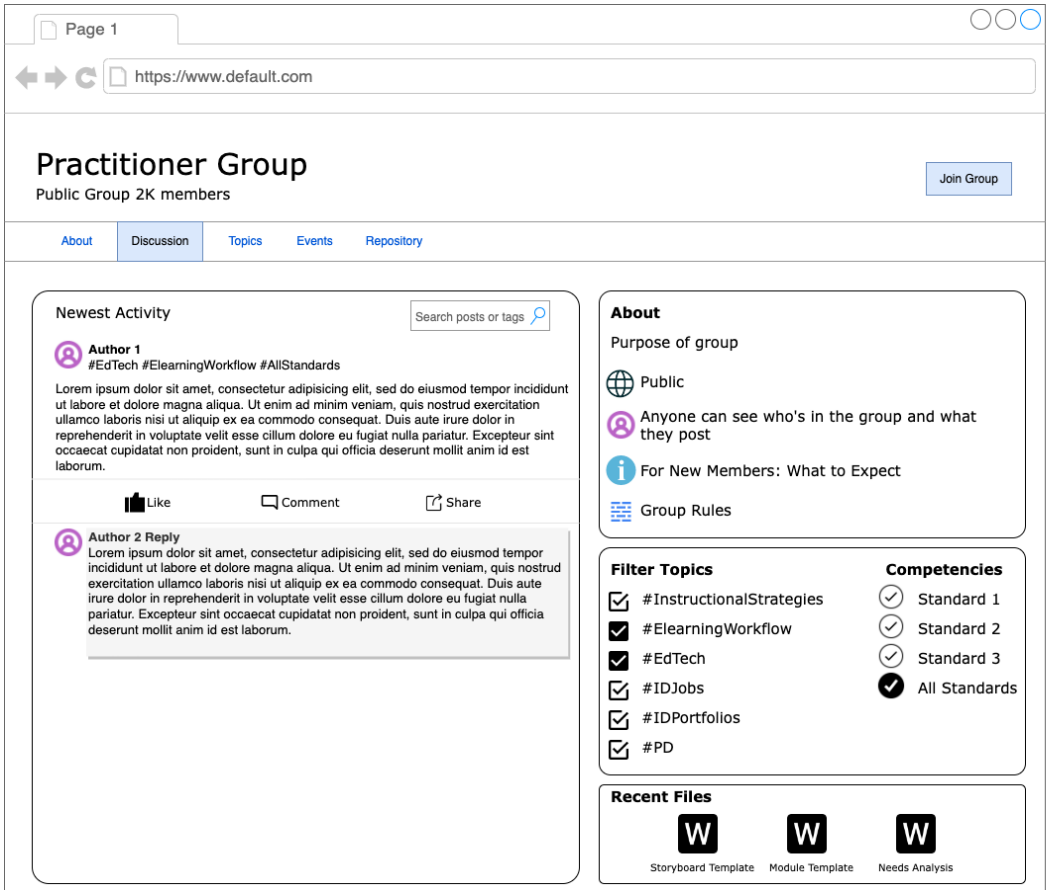
For study #2, the design recommendations can also be implemented in IDT CoPs on the Facebook social media platform. Figure 2 shows an online CoP in IDT that provides topic organizational schemes (design feature #1), statements of community protocols for addressing misinformation and onboarding of new members (design feature #2), and statements about the purpose, functions, and protocols (design feature #3). While IDT CoPs on Facebook have similar functions related to sharing advice about educational technology, online CoPs in IDT should implement the first three design features that allow members to manipulate better the organizational knowledge capital based on the organizational topic structures. In the first design feature, the second study's findings offer community leaders topic structures of practical knowledge representing organizational knowledge capital in individual online CoPs. In the second design feature,

online CoPs in IDT are prone to disseminating misinformation about learning myths and lack onboarding information for new members. In the third design feature, online CoPs should state their purpose, functions, and protocols required for member engagement. The second and third design feature can be easily implemented by including important information about the online CoP. However, IDT CoPs will require additional time to organize their practical knowledge into meaningful topic categories for the first design feature.

Although online CoPs in IDT on Facebook have a simple search engine function to look for information within the online environment, the fourth design feature involves augmenting the search engine function that ties the topic structures together to give community members a high-level overview of the available practical knowledge by topic or competency category. Future ICTs should increase the search engine functions to allow for high-level overviews of practical knowledge by generating insights from the online CoP from user posts for the fifth design feature.

Figure 2.

Wireframe of the Instructional Designer Facebook Group



Limitations

Despite the interesting findings, practical implications, and care for collecting the text sources, this three-article dissertation has limitations. External resources, including documents, videos, and graphics from online articles and users' posts, were not processed due to intensive tasks for scraping platforms and cleaning textual sources outside the e-learning news outlet and the Facebook platform. Additionally, responses from online articles were not scraped due to inconsistent comments in the e-learning development CoP (study #1). While practical knowledge in these online CoPs represents a given period, word frequencies and topic models may evolve as online CoPs may shift the direction of the discussion. Also, community leaders may engage in curation practices

and devise better organizational mechanisms for their platforms that are representative of the accumulated practical knowledge aligned with professional competencies.

Key Findings

Overall, this line of research is critical in understanding online CoPs that support the information needs of IDT practitioners, software companies, and educators. The series of studies has demonstrated that:

1. The E-Learning Industry CoP produced online articles as recommendations, evaluations, and reports on IDT practice's pedagogical and technical aspects (Leung, 2022). The online CoP in IDT heavily emphasized the production of online articles related to LMSs as the primary mechanism for e-learning courses for online employee onboarding, skills development, and compliance purposes. The online articles of this CoP were characterized by the digestible reading nature, the positive tone across the seven news categories, and the emphasis on educational technology over pedagogical entities. Additionally, the practical knowledge extracted from online articles emphasized the ease of implementation of LMSs with integration and support of e-learning authoring software and the best practices around the technical aspects of design and development concerning LMSs and e-learning authoring software. Although most online articles were written positively across the seven news categories, this online CoP did not provide explicit standards for controlling the quality of published online articles and vetting the credentials of SMEs. While the online CoP relies on CMS technology to manage the publication of practitioners' online articles, the E-Learning Industry should state the evaluation criteria for producing articles within

the current capabilities of a CMS. It is critical to cross-reference the online articles with other news categories related to the pedagogical foundations for supporting the decision-making of educational technology implementation. In addition, the E-Learning Industry can significantly improve the UX of accessing and cross-referencing practical knowledge with professional standards and competencies in IDT. This way, practitioners of varying degrees of professional experience can assess knowledge gaps that allow for better integration of new practical knowledge into their IDT practice.

2. The online CoPs in IDT found on the Facebook platform have specific purposes, shared and unique characteristics, and conventions for exchanging knowledge (Leung, 2022). In IDT CoPs, the four areas of knowledge exchange between the *Instructional Designer* and *Designers for Learning* Facebook groups were related to instructional design programs, job postings, events, and free resources. The unique characteristics of the *Instructional Designer* group were in the solicitation for reviewing instructional design portfolios and educational animation development. The unique features of *Designers for Learning* were related to serious games, online game development, and educational technology research. In e-learning development CoPs, the technical aspects of e-learning authoring tools are shared characteristics in the *Adobe Captivate Users* and *Articulate Storyline* Facebook groups. The unique features of the e-learning development CoPs involve the integration of e-learning courses with LMSs and JavaScript, respectively. Based on the findings of this study, it is critical for online CoPs in IDT to provide improved topic structures, establish community protocols for

correcting misconceptions about learning, align topic structures of e-learning authoring software in support sites and Facebook groups, provide better onboarding of new members, and define the purpose, functions, and curation practices for sharing practical knowledge.

3. The custom development of the online CoP for educators in NEE, the second generation of the EdHub Library, showed how an information space could be implemented to support users of different experience levels with teacher professional development and information tasks despite the current limitations of Web 2.0 technologies (Leung, 2021). Although the goal of the third study was to redesign the library from a usability perspective, the design decisions and the prototype interface can be implemented in other online CoPs to provide better mechanisms for community members to browse and locate practical knowledge independently. Despite the current limitations of Web 2.0 technologies, this study serves as a foundational piece for the future development of CoPs using the next generation of web technologies where platforms support community leaders and members with the monitoring and exchange of practical knowledge.

Conclusion

This three-article dissertation provided design recommendations for improving online CoPs as information spaces that advance the skills and knowledge of practitioners. The findings of the individual studies can be implemented to enhance online CoPs in IDT within the current limitations of ICTs based on Web 2.0 technologies. Currently, the online CoPs in IDT can improve various mechanisms for organizing their organizational knowledge capital based on the topic structures discovered through topic modeling,

including explicit statements for addressing misconceptions and evaluating the quality of codified knowledge produced by IDT practitioners. The future generation of ICTs can support members in monitoring the exchange of practical knowledge by integrating NLP pipelines that digest users' textual sources. At the same time, community leaders will benefit from the future generation of ICTs by observing the generation and exchange of practical knowledge at the administrative level and enable them to take appropriate actions to advance the skills and expertise of IDT practitioners.

Research is still needed to inform community leaders, software developers, and providers of professional development about (a) additional characteristics of community members' exchange of practical knowledge in asynchronous online environments, (b) the evolution of topic patterns over time as a critical indicator of online CoPs' priorities, and (c) the prototyping NLP dashboards to sustain knowledge creation processes. As community members exchange practical knowledge, future research can focus on the additional characteristics of codified knowledge through sentiment analysis of topic patterns to discover the challenging aspects of IDT practice. While web technologies enable the rapid creation of online CoPs using different platforms, the future direction of this research includes the development of a comprehensive entity dictionary from the first two studies to investigate other public online CoPs, such as Reddit, Quora, Twitter, and LinkedIn. As current platforms evolve and new ones emerge, a further investigation of the exchange of practical knowledge through rhetorical and linguistic analyses will inform fellow scholars and stakeholders about how these platforms facilitate or hinder community members. Although community dashboards are not currently integrated into Web 2.0 technologies, this line of research affords the testing of community dashboards

using NLP pipelines to assist online CoPs with quantifying the accumulated practical knowledge and facilitating self-directed learning among community members. The topic models generated in these dashboards can be shared as an open-source project in Streamlit or Dash to support the future development of ICTs, providing better support for online CoPs as information spaces.

References

2021 Impact Factors - Released. (n.d.). https://www.mdpi.com/about/announcements/4095

Abidi, S. S. R., Cheah, Y. N., & Curran, J. (2005). A knowledge creation info-structure to acquire and crystallize the tacit knowledge of healthcare experts. *IEEE Transactions on information technology in biomedicine*, *9*(2), 193-204. https://doi.org/10.1109/TITB.2005.847188

Al-Qdah, M. S., & Salim, J. (2013). A conceptual framework for managing tacit knowledge through ICT perspective. *Procedia Technology*, *11*, 1188-1194. https://doi.org/10.1016/j.protcy.2013.12.312

Bergeron, B. (2003). *Essentials of knowledge management* (Vol. 28). John Wiley & Sons.

Berners-Lee, T. (1996). WWW: Past, present, and future. *Computer*, *29*(10), 69-77. https://doi.org/10.1109/2.539724

Brockmann, E. N., & Anthony, W. P. (2002). Tacit knowledge and strategic decision-making. *Group & Organization Management*, *27*(4), 436-455. https://doi.org/10.1177/1059601102238356

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization science*, *2*(1), 40-57. https://doi.org/10.1287/orsc.2.1.40

Brugman, S. (2021.). *Introduction — pandas-profiling 3.0.0 documentation*. Pandas Profiling. Retrieved August 6, 2021, from https://pandas-profiling.github.io/pandas-profiling/docs/master/rtd/

Cairns, L., & Malloch, M. (2011). Learning in the workplace: Communities of practice and beyond. *The Sage handbook of workplace learning*, 73-85. https://doi.org/10.4135/9781446200940.n6

Campos, E. B., Moreno, C. M., & Landaeta, R. P. (2011). Sharing knowledge through communities of practice. In *Handbook of research on communities of practice for organizational management and networking: Methodologies for competitive advantage* (pp. 19-31). IGI Global. https://doi.org/10.4018/978-1-60566-802-4.ch002

Carlén, U., Jobring, O., Qvistgård, M., & Nilsen, M. (2004). Constituents of online learning communities. In *Proceedings for the IADIS International Conference on Web-based Communities* (pp. 341-348).

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442-455. https://doi.org/10.1287/orsc.13.4.442.2953

Chang, J., Gerrish, S., Wang, C., Boyd-Graber, J. L., & Blei, D. M. (2009). Reading tea leaves: How humans interpret topic models. Advances *in neural information processing systems* (pp. 288-296).

Chen, C. H., & Saeedi, M. (2006). Building a trust model in the online market place. *Journal of Internet commerce*, *5*(1), 101-115. https://doi.org/10.1300/J179v05n01_06

Collins, H. (2010). THREE. Explicable Knowledge. In *Tacit and Explicit Knowledge* (pp. 57-82). University of Chicago Press. https://doi.org/10.7208/chicago/9780226113821.001.0001

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Harvard Business Press.

Dawley, L. (2009). Social network knowledge construction: Emerging virtual world pedagogy. *On the Horizon, 17(*2), 109-121. https://doi.org/10.1108/10748120910965494

Dille, K. B., & Røkenes, F. M. (2021). Teachers' professional development in formal online communities: A scoping review. *Teaching and Teacher Education, 105*, 103431. https://doi.org/10.1016/j.tate.2021.103431

Ding, W., & Lin, X. (2009). Information architecture: The design and integration of information spaces. *Synthesis Lectures on Information Concepts, Retrieval, and Services*, *1*(1), 1-169. https://doi.org/10.2200/S00214ED1V01Y200910ICR008

Dudek, A., & Patalas-Maliszewska, J. (2016). A model of a tacit knowledge transformation for the service department in a manufacturing company: a case study. *Foundations of Management*, *8*(1), 175-188. https://doi.org/10.1515/fman-2016-0014

Erickson, T., & Kellogg, W. A. (2000). Social translucence: an approach to designing systems that support social processes. *ACM transactions on computer-human interaction (TOCHI)*, *7*(1), 59-83. https://doi.org/10.1145/344949.345004

Fung-Kee-Fung, M., Morash, R., & Goubanova, E. (2011). Evaluating CoPs in cancer surgery. In *Handbook of Research on Communities of Practice for Organizational Management and Networking: Methodologies for Competitive Advantage* (pp. 456-466). IGI Global. https://doi.org/10.4018/978-1-60566-802-4.ch025

Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult education quarterly*, *48*(1), 18-33. https://doi.org/10.1177/074171369704800103

Greene, S., Marchionini, G., Plaisant, C., & Shneiderman, B. (2000). Previews and overviews in digital libraries: Designing surrogates to support visual information seeking. *Journal of the American Society for Information Science*, *51*(4), 380-393. https://doi.org/10.1002/(SICI)1097-4571(2000)51:4%3C380::AID-ASI7%3E3.0.CO;2-5

Grootendorst, M. (2020). *GitHub - MaartenGr/BERTopic: Leveraging BERT and c-TF-IDF to create easily interpretable topics.* BERTopic. Retrieved August 6, 2021, from https://github.com/MaartenGr/BERTopic

Hao, J., Zhao, Q. F., Yan, Y., & Wang, G. X. (2016). A brief introduction to tacit knowledge and the current research topics. In *2016 International Conference on Machine Learning and Cybernetics (ICMLC)* (Vol. 2, pp. 917-921). IEEE. https://doi.org/10.1109/ICMLC.2016.7873009

Haythornthwaite, C. (2000). Online personal networks: Size, composition and media use among distance learners. *New Media & Society*, *2*(2), 195-226. https://doi.org/10.1177/14614440022225779

Herschel, R. T., Nemati, H., & Steiger, D. (2001). Tacit to explicit knowledge conversion: knowledge exchange protocols. *Journal of knowledge management*. https://doi.org/10.1108/13673270110384455

IEEE Open. (2022). *IEEE Access*. https://open.ieee.org/publishing-options/ieee-access/

International Journal of Designs for Learning. (n.d.). https://scholarworks.iu.edu/journals/index.php/ijdl/about

Jackson, T. W., Tedmori, S., Hinde, C. J., & Bani-Hani, A. I. (2012). The boundaries of natural language processing techniques in extracting knowledge from emails. *Journal of Emerging Technologies in Web Intelligence*, *4*(2), 119-127. https://doi.org/10.4304/jetwi.4.2.119-127

Jahnke, I., Schmidt, M., Pham, M., & Singh, K. (2020). Sociotechnical-Pedagogical Usability for Designing and Evaluating Learner Experience in Technology-Enhanced Environments. In M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw (Eds.), *Learner and User Experience Research: An Introduction for the Field of Learning Design & Technology*. EdTech Books. https://edtechbooks.org/ux/sociotechnical_pedagogical_usability

Johnson, C. M. (2001). A survey of current research on online communities of practice. *The internet and higher education*, *4*(1), 45-60. https://doi.org/10.1016/S1096-7516(01)00047-1

Kabir, N. (2013). Tacit knowledge, its codification and technological advancement. *Electronic Journal of Knowledge Management*, *11*(3), pp 235-243.

Kim, T., & Chi, S. (2019). Accident case retrieval and analyses: using natural language processing in the construction industry. *Journal of Construction Engineering and Management*, *145*(3), 04019004. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001625

Knowledge. (n.d.-a). https://www.mdpi.com/journal/knowledge/imprint

Knowledge. (n.d.-b). https://www.mdpi.com/journal/knowledge/indexing

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization science*, *3*(3), 383-397. https://doi.org/10.1287/orsc.3.3.383

Leung, J. (2018). Discovering Utilization Patterns in an Online K-12 Teacher Professional Development Platform: Clustering and Data Visualization Methods. *Quarterly Review of Distance Education*, *19*(3), 17-37.

Leung, J. (2021). Design features of online teacher professional development: A design case for re-developing the EdHub Library to improve usability and alignment of content with teacher standards. *International Journal of Designs for Learning*, *12*(2), 79-92. https://doi.org/10.14434/ijdl.v12i2.29578

Leung, J. (2022). Examining the Characteristics of Practical Knowledge from Four Public Facebook Communities of Practice in Instructional Design and Technology. *IEEE Access*, *10*, 90669-90689. https://doi.org/10.1109/access.2022.3201893

Leung, J. (2022). An NLP approach for extracting practical knowledge from a CMS-based community of practice in E-Learning. Knowledge, *2*(2), 310-336. https://doi.org/10.3390/knowledge2020018

Liew, A. (2007). Understanding data, information, knowledge and their inter-relationships. *Journal of knowledge management practice*, *8*(2), 1-16.

Limberg, L. (1999). Three conceptions of information seeking and use. *Exploring the contexts of information behaviour,* 116-135.

Limberg, L., & Sundin, O. (2006). Teaching information seeking: relating information literacy education to theories of information behaviour. *Information Research: an international electronic journal*, *12*(1), n1.

Lorian, S. (n.d.). *TextBlob: Simplified Text Processing — TextBlob 0.16.0 documentation*. TextBlob: Simplified Text Processing. Retrieved August 6, 2021, from https://textblob.readthedocs.io/en/dev/

Mäkäräinen-Suni, I., & Hong, J. (2011). Ba and communities of practice in research and strategic communities as a way forward. In *Handbook of research on communities of practice for organizational management and networking: Methodologies for competitive advantage* (pp. 46-69). IGI Global. https://doi.org/10.4018/978-1-60566-802-4.ch004

Macià, M., & García, I. (2016). Informal online communities and networks as a source of teacher professional development: A review. *Teaching and teacher education*, *55*, 291-307. https://doi.org/10.1016/j.tate.2016.01.021

Marett, K., & Joshi, K. D. (2009). The decision to share information and rumors: Examining the role of motivation in an online discussion forum. *Communications of the Association for Information Systems*, *24*(1), 4. https://doi.org/10.17705/1CAIS.02404

McArthur, R., & Bruza, P. (2003). Discovery of Tacit Knowledge and Topical Ebbs and Flows Within the Utterances of an Online Community. In *Chance Discovery* (pp. 115-132). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-06230-2_9

Meloni, G. & Villa, T. (2007). Uncovering tacit knowledge in projects. Paper presented at PMI® Global Congress 2007—EMEA, Budapest, Hungary. Newtown Square, PA: Project Management Institute.

Merelo-Guervós, J. J., Prieto, B., Prieto, A., Romero, G., Castillo-Valdivieso, P., & Tricas, F. (2004). Clustering web-based communities using self-organizing maps. In *IADIS International Conference Web Based Communities* (pp. 158-165).

Mohamed, R., Ferguson, J. D., Elsweiler, D., MacCormick, A., Wilson, J., & Weir, G. R. (2004). BulB-visualizing bulletin board activity. In *Proceedings of the 6th International Conference on Enterprise Information Systems*.

Mohanan, M., & Samuel, P. (2016). Software requirement elicitation using natural language processing. In *Innovations in Bio-Inspired Computing and Applications* (pp. 197-208). Springer, Cham. https://doi.org/10.1007/978-3-319-28031-8_17

Muljana, P. S., Austion, K., Jutzi, K., Pezzell, L. B., & Pytel, M. G. (2021). Free Asynchronous Professional Development By, From, and For Instructional Designers: How Informal Learning Opportunities Shape Our Professional Learning and Design Practices. *The Journal of Applied Instructional Design*, *10*(3). https://doi.org/10.51869/103/pmkjkagplp

Natural Language Toolkit — NLTK 3.6.2 documentation. (n.d.). Natural Language Processing Toolkit - NLTK. Retrieved August 6, 2021, from https://www.nltk.org/

Nielsen, J. (1994). Usability inspection methods. In *Conference companion on Human factors in computing systems* (pp. 413-414). https://doi.org/10.1145/259963.260531

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford university press. https://doi.org/10.1016/0024-6301(96)81509-3

Novak, J., Fleischmann, M., Strauss, W., Schneider, M., Wurst, M., Morik, K., ... & Kunz, C. (2002). Augmenting the knowledge bandwidth and connecting heterogeneous expert communities through uncovering tacit knowledge. In *Proceedings. IEEE Workshop on Knowledge Media Networking* (pp. 87-92). IEEE. https://doi.org/10.1109/KMN.2002.1115168

Polanyi, M. (1966). The tacit dimension (2009 ed.).

O'Dowd, R., & Dooly, M. (2022). Exploring teachers' professional development through participation in virtual exchange. *ReCALL, 3*4(1), 21-36. https://doi.org/10.1017/S0958344021000215

Önday, Ö. (2019). Web 6.0: Journey From Web 1.0 To Web 6.0. *Journal of Media & Management, SRC/JMM-102*. https://doi.org/10.47363/JMM/2019(1)102

Oyarzun, D., Ortiz, A., & del Puy Carretero, M. (2011). Future Tools for Sharing Knowledge: Virtual Communities in the Web3D. In *Handbook of Research on Communities of Practice for Organizational Management and Networking: Methodologies for Competitive Advantage* (pp. 283-295). IGI Global. https://doi.org/10.4018/978-1-60566-802-4.ch016

Probst, G., Raub, S., & Romhardt, K. (2000). *Managing knowledge: Building blocks for success* (Vol. 360). Chichester: John Wiley & Sons.

Rafaeli, S., Ravid, G., & Soroka, V. (2004, January). De-lurking in virtual communities: A social communication network approach to measuring the effects of social and cultural capital. In *37th Annual Hawaii International Conference on System Sciences, 2004. Proceedings of the* (pp. 10-pp). IEEE. https://doi.org/10.1109/HICSS.2004.1265478

Ray, D. (2006). The life cycles of communities of practice. In *Encyclopedia of communities of practice in information and knowledge management* (pp. 323-326). IGI Global. https://doi.org/10.4018/978-1-59140-556-6.ch055

Rebers, S., Aaronson, N. K., van Leeuwen, F. E., & Schmidt, M. K. (2016). Exceptions to the rule of informed consent for research with an intervention. *BMC medical Ethics*, *17*, 1-11. https://doi.org/10.1186/s12910-016-0092-6

Řehůřek, R. (2009). *Gensim: topic modelling for humans*. Topic Modelling for Humans. Retrieved August 6, 2021, from https://radimrehurek.com/gensim/

Reimers, N. (2021). *Pretrained Models — Sentence-Transformers documentation*. Pre-Trained Models. https://www.sbert.net/docs/pretrained_models.html

Ronen, T., & Pasher, E. (2011). *The complete guide to knowledge management: A strategic plan to leverage your company's intellectual capital*. John Wiley & Sons. https://doi.org/10.1002/9781118983782

Sanz, S., & Pérez-Montoro, M. (2011). Conceptual foundations of communities of practice as organizational structures. In *Handbook of Research on Communities of Practice for Organizational Management and Networking: Methodologies for Competitive Advantage* (pp. 83-100). IGI Global. https://doi.org/10.4018/978-1-60566-802-4.ch006

Satsangi, P. (2019). Automation of Tacit Knowledge Using Machine Learning. In *2019 6th International Conference on Soft Computing & Machine Intelligence (ISCMI)* (pp. 35-39). IEEE. https://doi.org/10.1109/ISCMI47871.2019.9004290

Scaccia, J. P., & Scott, V. C. (2021). 5335 days of Implementation Science: using natural language processing to examine publication trends and topics. *Implementation Science, 16*(1), 1-12. https://doi.org/10.1186/s13012-021-01120-4

Schwier, R. A., Campbell, K., & Kenny, R. (2004). Instructional designers' observations about identity, communities of practice and change agency. *Australasian Journal of Educational Technology*, *20*(1). https://doi.org/10.14742/ajet.1368

Shipman, T. (2015). In-Service Teachers and their Information-Seeking Habits: Does Library Instruction Show a Relationship to Information-Seeking Habits for Professional Use?. *National Teacher Education Journal*.

Seufert, S., Lechner, U., & Stanoevska, K. (2002). A reference model for online learning communities. *International Journal on E-learning*, *1*(1), 43-54.

spaCy · Industrial-strength Natural Language Processing in Python. (n.d.). spaCy - Industrial-Strength Natural Language Processing. Retrieved August 6, 2021, from https://spacy.io/

Stenmark, D. (2002). Information vs. knowledge: The role of intranets in knowledge management. In *Proceedings of the 35th Annual Hawaii International Conference on System Sciences* (pp. 928-937). IEEE.

Stone, A., & Sawyer, P. (2006). Identifying tacit knowledge-based requirements. *IEEE Proceedings-Software*, *153*(6), 211-218. https://doi.org/10.1049/ip-sen:20060034

Stuckey, B., & Smith, J. D. (2004). Building sustainable communities of practice. In *Knowledge networks: Innovation through communities of practice* (pp. 150-164). IGI Global. https://doi.org/10.4018/978-1-59140-200-8.ch014

Suppiah, V., & Sandhu, M. S. (2011). Organisational culture's influence on tacit knowledge-sharing behaviour. *Journal of knowledge management*. https://doi.org/10.1108/13673271111137439

Taskin, Z., & Al, U. (2019). Natural language processing applications in library and information science. *Online Information Review*. https://doi.org/10.1108/OIR-07-2018-0217

Usun, S. (2009). Information and communications technologies (ICT) in teacher education (ITE) programs in the world and Turkey:(a comparative review). *Procedia-Social and Behavioral Sciences*, *1*(1), 331-33.4 https://doi.org/10.1016/j.sbspro.2009.01.062

Veremyev, A., Semenov, A., Pasiliao, E. L., & Boginski, V. (2019). Graph-based exploration and clustering analysis of semantic spaces. *Applied Network Science*, *4*(1), 1-26. https://doi.org/10.1007/s41109-019-0228-y

Wagner, R. K., & Sternberg, R. J. (1985). Practical intelligence in real-world pursuits: The role of tacit knowledge. *Journal of personality and social psychology*, *49*(2), 436. https://doi.org/10.1037/0022-3514.49.2.436

Wei, C. P., Yang, C. C., & Lin, C. M. (2008). A latent semantic indexing-based approach to multilingual document clustering. *Decision Support Systems*, *45*(3), 606-620.

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems thinker*, *9*(5), 2-3.

Wenger, E. (2011). Communities of practice: A brief introduction.

Wenger, E., McDermott, R. A., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard business press.

Wenger, E. C., & Snyder, W. M. (2000). Communities of practice: The organizational frontier. *Harvard business review*, *78*(1), 139-146.

Williams, M. L., Burnap, P., Sloan, L., Jessop, C., & Lepps, H. (2017). Users' views of ethics in social media research: Informed consent, anonymity, and harm. In *The ethics of online research*. Emerald Publishing Limited. https://doi.org/10.1108/S2398-601820180000002002

Zappavigna, M. S. (2006). Tacit knowledge in communities of practice. In *Encyclopedia of communities of practice in information and knowledge management* (pp. 508-513). IGI Global. https://doi.org/10.4018/978-1-59140-556-6.ch08

Zuppo, C. M. (2012). Defining ICT in a boundaryless world: The development of a working hierarchy. *International journal of managing information technology*, *4*(3), 13. https://doi.org/10.5121/ijmit.2012.4302

Appendices

Appendix 1-Article 1: An NLP Approach for Extracting Practical Knowledge from a CMS-Based Community of Practice in E-Learning

Article 1: published in *Knowledge.*

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Article

An NLP Approach for Extracting Practical Knowledge from a CMS-Based Community of Practice in E-Learning

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Abstract: This study aimed to identify the tacit or practical knowledge of an online community of practice (CoP) based on a content management system (CMS) technology. The E-Learning Industry site is one of the most prominent news outlets that provides instructional design and technology (IDT) practitioners with insights into the field. Natural language processing (NLP) techniques were implemented to extract practical knowledge of publicly available and not password-protected text sources in seven news categories. First, the findings suggest emphasizing the production of online articles related to the production of e-learning materials in technology-enabled environments. Second, the results indicate the alternative uses of learning management systems to manage different aspects of the production of e-learning materials. Third, the findings show that the CoP's main priority was to reference existing materials in the community and external resources. The results of this study have implications and provide recommendations for researchers, community leaders, and practitioners toward improving knowledge discovery mechanisms, increasing transparency and integrity in communities, and increasing practitioners' ability to self-assess existing practical knowledge against competencies in the field. The present study takes an inventory of the organizational knowledge capital and functions embedded in a CoP using a CMS platform as a delivery mechanism for creating and sharing knowledge.

Keywords: topic modeling; data mining; instructional design; online learning; knowledge management; communities of practice

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1. Introduction

Becoming an instructional designer requires formal training from curricular activities and practical experiences from internships that are similarly borrowed from other design fields, such as engineering and architecture [1]. Much of the literature on becoming an instructional designer has emphasized training methods to improve formal training. Though the literature offers formal methods of instructional design training in the form of design studio approaches, case studies, competitions, internships, and expert demonstrations that address the complexity of design problems and solutions, the practical aspects of instructional design work appear in the form of informal learning in the workplace [2–4] and educational experiences in adult and continuing education [5].

Information Communication and Technology (ICT) tools play an important role in supporting formal and informal learning activities through interconnected technological ecosystems that enable individuals to learn intentionally or unintentionally through Massive Online Open Courses (MOOCs), communities of practice (CoPs), and social media platforms [6]. Web 2.0 technologies allow individuals to create and distribute content [7]. Examples of Web 2.0 platforms are social networking sites (e.g., Facebook and LinkedIn), blog platforms (e.g., Blogger, Reddit, and WordPress), content and learning management systems (e.g., Drupal, Joomla, WordPress, Canvas, and Blackboard), and photo and video platforms (e.g., Instagram and YouTube).

Due to the rise of ICT tools and the open-source nature of content management systems (CMS), CoPs can deploy online communities based on Drupal, Joomla, or WordPress. Online CoPs can deliver informal learning opportunities and resources that address the needs and gaps of instructional designers [8]. As instructional designers expand their tacit or practical knowledge, informal learning experiences progressively allow practitioners to refine their skills over time. Informal learning is unplanned, unstructured, and incidental learning beyond formal settings and is not bound to a specific place and time [9,10]. Informal learning is also influenced by the presence or absence of the intentionality and consciousness of learning that can take place in the form of self-directed learning or implicit learning [11]. In self-directed learning, learners attempt learning activities that are conscious and intentional. In contrast, in implicit learning, learners are immersed in a context where they are not consciously trying to learn the subject.

The E-Learning Industry news outlet is an example of an online CoP that offers informal learning opportunities for learning the practical aspects of instructional design and technology (IDT). The E-Learning Industry site is based on a CMS that uses WordPress as a blog-publishing system to manage web content and users [12]. This online CoP has invited practitioners to publish online articles related to practical knowledge of the field since 23 February 2012 [13,14]. Their practical knowledge is organized into seven news categories that represent the general organization of online articles as follows: (1) Learning Management Systems, (2) E-Learning software, (3) E-Learning Trends, (4) Design and Development, (5) Instructional Design, (6) Best Practices, and (7) Free Resources. According to the website traffic report by Similarweb [15], the E-Learning Industry site attracts 389,312 unique monthly visitors, as of February 2022. The majority of the web traffic comes from the United States, India, the Philippines, the United Kingdom, and Canada. The organic keywords that generate free traffic to the site include *learning management system*, *advantages of online education*, *pros and cons of online learning*, and *forgetting curve*.

Studies in the knowledge management literature examine tacit knowledge extraction from explicit forms of knowledge in the workplace (e.g., online platforms, documents, and e-mail communication). These studies are explored through the SECI model, where knowledge is continuously created through socialization, externalization, combination, and internalization [16]. First, tacit knowledge is created through a socialization process, and its tacitness is difficult to codify into explicit knowledge. Second, tacit knowledge is externalized or articulated in symbolic language for sharing with other groups or individuals. Third, the combination step requires applying and reorganizing explicit knowledge. Fourth, when explicit knowledge is applied, individuals embody the knowledge as tacit through action and reflection. This present study aims to extract tacit or practical knowledge from explicit knowledge in text artifacts occurring at the externalization stage.

The contributions of this work include filling a gap in the IDT literature and creating a baseline for future studies that improve the mechanisms for sharing practical knowledge in alignment with professional competencies. First, the characteristics of practical knowledge among IDT CoPs in virtual environments are unknown in the IDT literature. While present studies examine instructional designers' professional development needs and roles in academic and corporate settings, exploring sources of practical knowledge in a virtual environment is required to understand the current knowledge structures and gaps in instructional design knowledge. Second, this study establishes a foundation for future studies that supports the development of intelligence and recommendation systems that allow practitioners to make better use of online resources for skill development and to detect misinformation about learning. The study explores the following research questions:

- RQ 1: What are the text characteristics, most frequent words, and word sequences used in the online community?
- RQ 2: What are the characteristics of sentiment, named entities, and relationships among entities in the online community?
- RQ 3: What are the latent topic structures in the online community?

The rest of the article is organized as follows. Section 2 provides a literature review and related studies. Section 3 describes the research methodology, including a thorough description of the natural language processing (NLP) tasks performed. Section 4 describes the results of NLP tasks organized by the research question. Section 5 contains a discussion of results, implications for research and practice, limitations, and recommendations for improving the CoP of interest. Finally, Section 6 concludes the article and provides the future direction of this work.

2. Background

Four concepts are essential to consider in the context of the study. These concepts include communities of practice, professional organizations in IDT, the characteristics and extraction of tacit or practical knowledge from unstructured or textual data, and related studies of online news sources using NLP.

2.1. Communities of Practice in Instructional Design

Wenger [17] coined the term *communities of practice* (CoP) to examine the learning among practitioners in a social environment. Wenger and Synder [18] described CoPs as groups of people informally gathered to share expertise in a specific domain or field as they interact regularly. Yanchar and Hawkley [1] argued that instructional design practitioners are willing to engage in informal learning efforts that address rapidly changing work situations. Online CoPs provide professional connections and supporting mechanisms with geographically dispersed members through ICT tools [19].

Schwier et al. [20] argued that instructional design CoPs are born of the convenience that allows informal engagement to solve specific project challenges or issues. The authors also investigated the features of instructional design CoPs in terms of history and culture, mutuality, plurality, and tacit knowledge. They found that shared history and culture are not prominent features in instructional design CoPs. In contrast, passive participation as a spectator was a critical element aligned with practitioners' agendas and community values. In terms of mutuality, community members developed their protocols for contribution and interaction with others. At the same time, community participation was based on the plurality of intermediate relationships with other members (i.e., experts in the field), which provided a wide range of considerations and solutions to learning problems.

Furthermore, Schwier et al. [21] investigated the types of agency or sense of responsibility that instructional designers hold in instructional design communities, their profession, and their respective work contexts. Interpersonal agency refers to one's capacity to exert control or influence the processes and outcomes of instructional design projects. Professional agency refers to the feeling of responsibility to the profession and community by acting in a professionally competent manner. Institutional agency refers to the sense of responsibility to advance the organization's agenda, which instructional designers represent. Societal agency is characterized by the sense of a contribution to society through instructional design work. Instructional design communities are also knowledge repositories where members can draw upon practical knowledge as members collectively transform tacit knowledge into explicit forms in informal and serendipitous ways. Examples of practical knowledge include unique or creative solutions to dealing with demanding clients, job aids or templates for applying criteria to projects, and expert advice to solve complex problems. Interestingly, the authors of [21] pointed out that healthy communities collaboratively rely on designing solutions to complex problems.

2.2. Instructional Design Competencies

Due to the absence of a recognized accrediting body that identifies the required competencies for IDT professionals, professional organizations have developed the competencies that define professionals' knowledge, skills, and abilities. Professional organizations use competencies to encapsulate professional benchmarks, responsibilities, and capabilities in different roles (e.g., training manager, evaluator, instructional designer, or instructional tech-

nologist). These competencies come from the American Talent Development (ATD) [22], the International Board of Standards for Training, Performance, and Instruction (IBSTPI) [23], the Association for Educational Communications and Technology (AECT) [24], and the International Society for Technology in Education (ISTE) [25].

2.3. Tacit Knowledge Characteristics and Extraction

Polanyi [26] initially introduced tacit knowledge with the assertion that "we know more than we can tell" regarding individuals' "know-how", "working knowledge", "expertise", or a set of abilities to perform a job that is difficult to articulate or transfer to others explicitly. Wagner and Sternberg [27] defined tacit knowledge as work-related practical knowledge learned informally through experience on the job, concerned with knowing how instead of knowing what.

McAdam et al. [28] stated that tacit knowledge has technical and cognitive dimensions that contain mental models, values, beliefs, and perceptions. Tacit cognitive knowledge incorporates implicit mental models and perceptions that allow individuals to understand their surroundings and tasks. Tacit technical knowledge is workers' knowledge and abilities to perform functions that are not easily articulated. Viale and Pozzali [29] argued that different forms of tacit knowledge could be acquired and transmitted in the form of competencies, background knowledge, and implicit cognitive rules, as defined below:

- Tacit knowledge as a competence refers to the skills and abilities acquired through apprenticeships and face-to-face interactions.
- Tacit background knowledge is the regulations, codes of conduct, and processes of acculturation to which individuals adhere, based on their context.
- Tacit knowledge acts as a mechanism for creating new knowledge and assessing the accuracy of information itself.

Steiger and Steiger [30] argued that tacit knowledge structures represent the implicit mental models of individuals. Mental models are tacit, where knowledge structures integrate the ideas, practices, assumptions, beliefs, relationships, facts, and misconceptions that individuals use to perceive and interact with others [31]. The authors [30] argued that tacit knowledge could be extracted from externalized knowledge through artificial neural networks and decision trees that perform the cognitive mapping of decision processes. Additionally, NLP algorithms are implemented to elicit, extract, and represent tacit knowledge from individuals and artifacts [32–38].

2.4. NLP Studies on Online News Sources

Online news outlets play a critical role in society, as a place where readers can learn about events, people, places, and trends. Additionally, online news outlets position themselves as credible information sources that provide readers with multiple perspectives on a given subject while producing information at a tremendous speed. However, studies of online news outlets using NLP have raised concerns about selectivity, misinformation, and transparency, which have had cognitive consequences for readers who encountered pieces of evidence, warrants, and claims to support persuasive written communication [39]. These studies have also identified the lack of mechanisms to improve the credibility, inclusivity, and fact-checking of online news articles. Ethical critiques of online news sources can identify the issues mentioned above through NLP techniques to detect the emerging contexts and classify online articles based on a given set of features. For instance, Srivastav and Singh [40] implemented a topic modeling approach to determine the contexts emerging from online news categories. Shang et al. [41] developed an application for auditing the production of published articles by detecting diversity, equity, and inclusion (DEI) indicators. Fung et al. [42] created an application for detecting users' sentiments and stances when reacting to news articles on social media. Singh and Singh [43] used a text similarity method to identify the issue of selectivity across various online news sources. Yu et al. [44] proposed a transformer-based machine learning technique for NLP to detect persuasion techniques in propagandistic news on social media. Gao et al. [45] performed supervised

and unsupervised NLP tasks on construction-related news outlets to classify and detect risk narratives. Jaidka et al. [46] implemented deep learning models to study persuasive communication in editing actions from Wikipedia Talk pages and predict editorial behavior and emotional change among contributors.

3. Materials and Methods

A total of 9033 online articles from April 2012 to September 2020 were scraped across seven news categories. The text sources from each news category were publicly available and required no password authentication to access the online articles. Each news category was identified based on the sitemap of the website to avoid the duplication of articles within and across categories. By obtaining all the links for each category, articles were scraped to include the title and body of the article, without author information. Table 1 shows the number of scraped articles for each news category.

Table 1. Number of online articles by news category.

News Category	Number of Articles
Learning Management System	927
E-Learning Software	400
E-Learning Trends	2934
Design and Development	2415
Instructional Design	1065
Best Practices	972
Free Resources	320
Total	9033

The average word and sentence lengths, word frequencies, and trigrams were generated as an exploratory step to understand the lengths of online articles, word frequencies, and probabilities of words appearing together. A stop words dictionary was not implemented in the average word and sentence lengths to count all words in the texts. In contrast, word frequencies and trigrams required a stop words dictionary to filter extraneous frequencies of common words, including articles, prepositions, pronouns, and conjunctions. After using a stop words dictionary, sentiment analysis, entity recognition, entity relationships, and topic modeling were implemented to extract sentiment polarity, pedagogical and educational technology entities and their relationships, and emerging themes from a news category. The remainder of this section describes the details of each NLP task performed in the study. Table 2 lists the Python packages used in the study.

Table 2. Summary of Python packages.

NLP Task	Python Package
Text characteristics	Lambda functions to calculate average word and sentence lengths
Visualization	Profile Report to visualize text characteristics
Sentiment analysis	TextBlob
Trigrams	NLTK
NER	spaCy
Topic modeling	Gensim for Latent Dirichlet Allocation and BERTopic (stsb-bert-large pre-trained model)

To address the first research question, the average word and sentence lengths of the online articles were generated using the lambda functions to explore text characteristics without filtering out stop words to account for all words. The generated features for each news category were visualized in the Profile Report package [47]. Additionally, word frequencies were visualized with the WordCloud package to identify prominent words in each news category [48]. Word frequencies were obtained after performing NLP tasks for cleaning, normalizing, and parsing using the Natural Language Toolkit (NLTK) by

performing lower casing, tokenization, stop word removal, lemmatization, stemming, and tagging parts-of-speech (POS). Though there is no consensus on using a standard stop word dictionary, the removal of stop words from textual data is a typical pre-processing step to remove noise or low-level information and reduce training time and dimensionality from uninformative words [49,50]. This study implemented the stop word English dictionary, Wordnet Lemmatizer, SnowBall Stemmer, and POS tagger libraries in NLTK. The NLTK n-gram language model package was implemented to create the probabilities of contiguous words in trigrams [51]. The most frequent trigrams were reported to illustrate word sequences in order to explore the context of the words.

To address the second research question, this study employed sentiment analysis, entity recognition, and entity relationships approaches. The TextBlob package was implemented for sentiment analysis to identify positive, neutral, and negative attitudes in the texts [52]. Online articles were classified as positive (1), neutral (0), and negative (−1). The spaCy package was implemented for the named entity recognition (NER) tasks to extract the names of people, places, organizations, and geographic locations [53]. Once entities were extracted, subject–object relationships emerged as entity pairs, allowing an understanding of how entities were referenced. These entity pairs consisted of the source and target entities linked by edge entities that defined the relationships among the entities.

In the third research question, the Latent Dirichlet Allocation (LDA) and BERTopic packages were used for topic modeling to discover latent topic patterns in each news category. In the first two rounds of topic modeling using LDA, the LDA topic modeling algorithm in the Gensim library generated word representations and probabilities using the bag-of-words (BoW) and Term Frequency–Inverse Document Frequency (TF-IDF) to predict emerging topic patterns in online articles from each news category [54]. The third model used sentence transformers with the BERTopic library using a class-based TF-IDF (c-TF-IDF) [55,56].

The LDA algorithm required a specific parameter for determining the exact number of topics that the algorithm used to achieve distinct and coherent topics. The ideal number of topics (n_topics) was achieved by running the LDA several times with multiple topic parameters from 2 to 20 until the elbow method achieved the highest coherence or C_v value. LDA also required parameters for the Dirichlet hyperparameter *alpha* for document–topic density and Dirichlet hyperparameter *beta* for word–topic density. The *alpha* and *beta* parameters were set to 'auto,' allowing the LDA algorithm to estimate the document–topic and word–topic densities automatically. With the BoW model, the TF-IDF model was generated to measure the importance of words against the whole corpus in the category. TF-IDF generated features or classes based on the term frequency of words and their weights in a document compared with their frequencies across all documents within a category.

In the third model, the BERTopic used sentence transformers and c-TF-IDF to calculate words' left and right contexts, generating clusters for topic interpretation. In c-TF-IDF, text sources are treated as a single class. Then, the frequency of each word was extracted and divided by the total number of words and documents across all classes. With BERTopic, the pre-trained sentence transformer model (stsb-bert-large) was implemented to identify semantic textual similarity by reducing dimensionality with the Uniform Manifold Approximation and Projection for Dimension Reduction technique (UMAP) and clustering sentence embeddings with the HDBSCAN algorithm [55].

Chang et al. [57] argued that there is no gold standard for evaluating topic models. Semantically coherent topics were examined through human judgment and quantitative approaches. Chang et al. [57] proposed evaluating topic model outputs using two methods, including topic and word intrusion methods. Regarding topic intrusion, discovered topics were evaluated based on whether the topic model's decomposition of the text sources agreed with human judgment based on domain expertise. In addition, a topic model was examined in terms of word intrusion by observing the words inserted in a topic model that did not provide semantic coherence or coherent meaning.

The semantic coherence values of topic models were also assessed quantitatively by obtaining semantic coherence measures, or C_v values. Semantic coherence measures describe how often topic words appear together in the corpus [58]. Table 3 summarizes the C_v values and the parameters for the ideal number of topics that resulted in semantically coherent topic models for each news category.

Table 3. C_v values and number of topics parameter for the LDA algorithm.

News Category	C_v	N_Topics Parameter
1. Learning Management System	0.488	7
2. E-Learning Software	0.437	4
3. E-Learning Trends	0.465	3
4. Design and Development	0.377	9
5. Instructional Design	0.438	5
6. Best Practices	0.422	3
7. Free Resources	0.356	10

Ethical Considerations

Even though web scraping is still a relatively new and emerging practice, Krotow and Silva [59] argued that ethical issues are associated with the automatic extraction of information. According to the authors, web scraping brings forth five ethical considerations: individual privacy and the rights of research participants, discrimination and bias, organization privacy, diminishing organizational value, and impacts on decision making. Even though web scraping involves ethical hurdles for academic researchers, and the Terms of Service (TOS) explicitly prohibit web scraping and the crawling of their platforms, Mancosu and Vegetti [60] noted that scraping public information from online platforms may be safe for researchers because research on social media serves the public interest. Additionally, Catanese et al. [61] argued that TOS is designed to disrupt the status quo by enforcing behavioral and technical limitations to web scraping.

While technology plays a critical role in sustaining knowledge creation and sharing, technology can have negative consequences when comparing several online CoPs because of the lack of anonymity and privacy, which leads to the unintended identification of users (e.g., searching for articles or posts on their platforms) who choose to participate in communities. For this particular reason, any identifiable information (i.e., links to articles and authorship) was deleted to ensure the anonymity and privacy of authors from the e-learning news outlet. Text sources are not publicly available to prevent plagiarism and to protect the community's organizational knowledge [62].

4. Results

4.1. RQ1: What Are the Text Characteristics, Most Frequent Words, and Word Sequences Used in the Online Community?

4.1.1. Text Characteristics

The below text characteristics accounted for all words in online articles without filtering stop words. In the Learning Management System category, the average word count was 1214.37 words, and the average sentence count was 58.75 sentences. The E-Learning Software category contained an average word count of 946.00 words and an average sentence count of 51.50 sentences. In the E-Learning Trends category, the average word count was 690.35 words, and the average sentence count was 37.51 sentences. The Design and Development category contained an average word count of 661.33 words and an average sentence count of 35.88 sentences. The Instructional Design category had an average word count of 681.25 words and an average sentence count of 36.76 sentences. In the Best Practices category, the average word count was 670.81 words, and the average sentence count was 36.68 sentences. In the Free Resources category, the average word count was 523.19 words, and the average sentence count was 28.25 sentences. The word and sentence length distributions are reported in Figure 1.

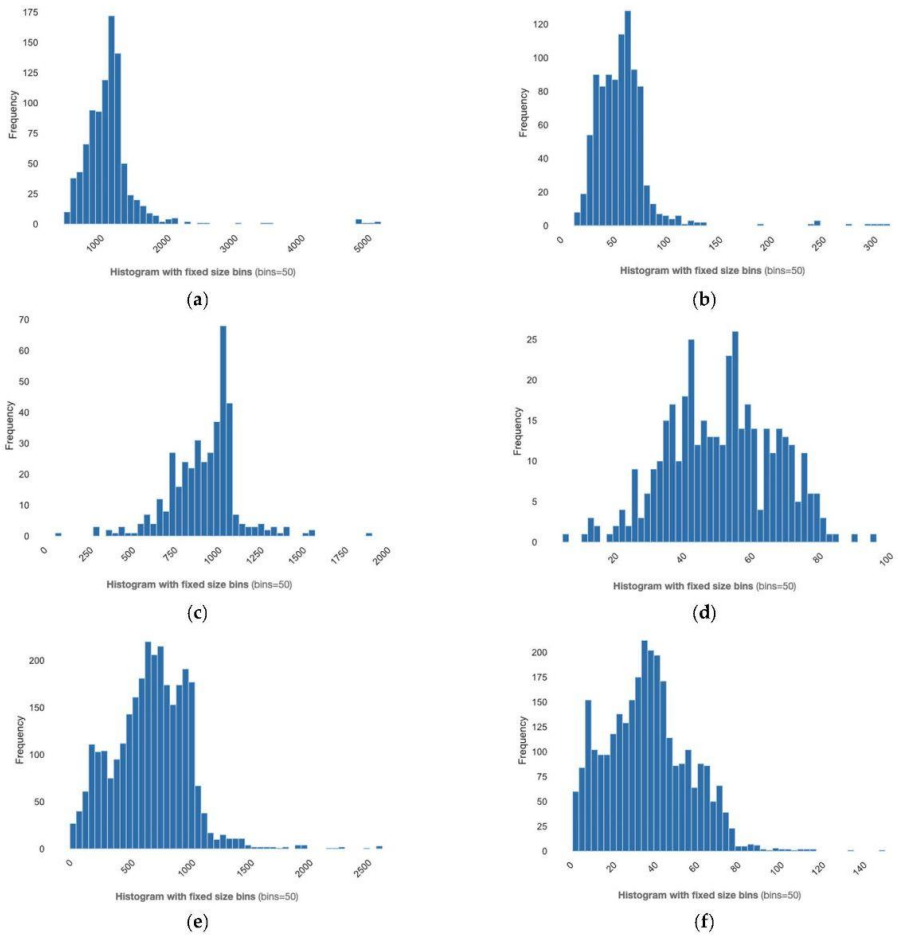


Figure 1. *Cont.*

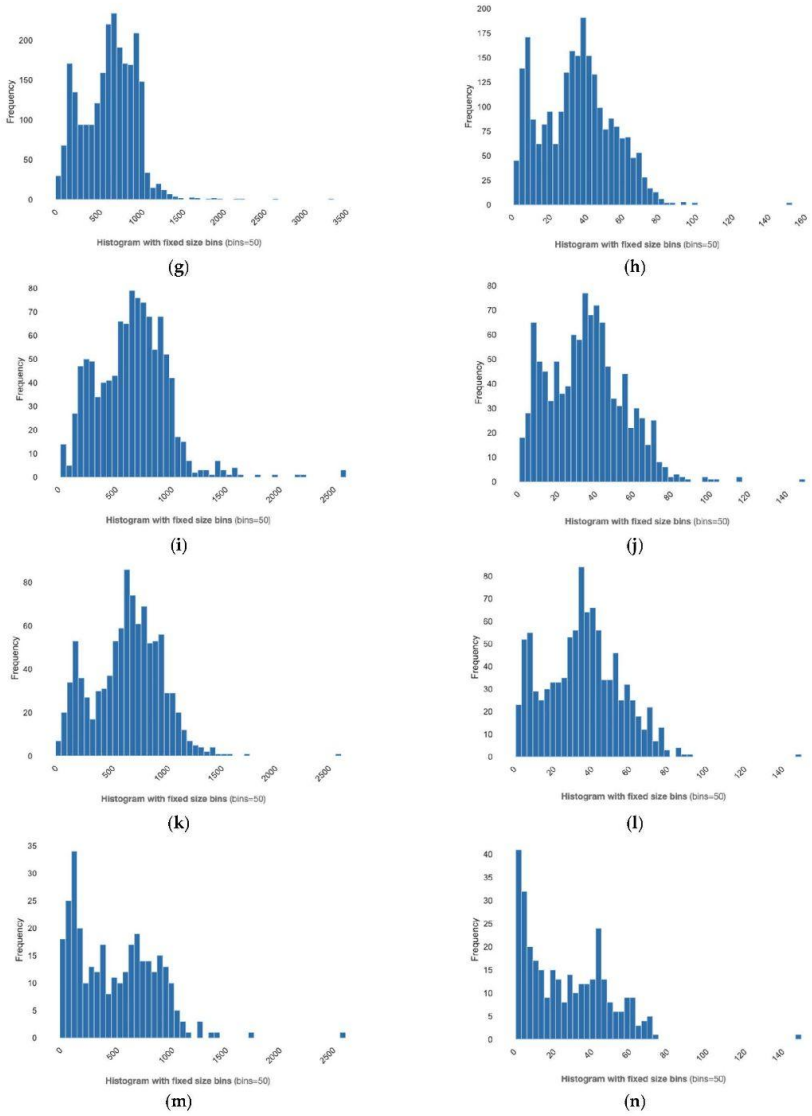


Figure 1. Distributions of the word and sentence lengths in each news category: (**a**) Learning Management System avg. word length; (**b**) Learning Management Systems avg. sentence length; (**c**) E-Learning Software avg. word length; (**d**) E-Learning Software avg. sentence length; (**e**) E-Learning Trends avg. word length; (**f**) E-Learning Trends avg. sentence length; (**g**) Design and Development avg. word length; (**h**) Design and Development avg. sentence length; (**i**) Instructional Design avg. word length; (**j**) Instructional Design avg. sentence length; (**k**) Best Practices avg. word length; (**l**) Best Practices avg. sentence length; (**m**) Free Resources avg. word length; (**n**) Free Resources avg. sentence length.

4.1.2. Word Frequencies

After performing text processing and using a stop words dictionary, the most frequent words from the online articles emerged as unique tokens or words that were the most representative of the category. Based on the size of the dictionary after removing stop words, the following list ranks the number of unique words found in each category in descending order:

1. Category 3: E-Learning Trends (36,321 words);
2. Category 4: Design and Development (30,808 words);
3. Category 5: Instructional Design (19,615 words);
4. Category 6: Best Practices (19,102 words);
5. Category 1: Learning Management System (17,580 words);
6. Category 2: E-Learning Software (11,325 words);
7. Category 7: Free Resources (9481 words).

In first place, the E-Learning Trends category had the largest dictionary, and the three most frequent words were *learner* (7360), *need* (5958), and *use* (5122). In second place, the three most frequent words in the Design and Development category were *learner* (6269), *need* (5355), and *elearning course* (4976). In third place, the three most frequent words in the Instructional Design category were *learner* (2858), *learning* (2310), and *need* (2115). In fourth place, the three most frequent words in the Best Practices category were *learner* (2642), *student* (2588), and *course* (2107). In fifth place, the three most frequent words in the Learning Management System category were *need* (4799), *lms* (4699), and *will* (3356). In sixth place, the three most frequent words in the E-Learning Software category were *need* (1514), *online training* (1468), and *lms* (1465). In seventh place, the three most frequent words in the Free Resources category were *elearning* (678), *learning* (648), and *will* (590). Figure 2 shows the word cloud visualizations that represent word frequencies.

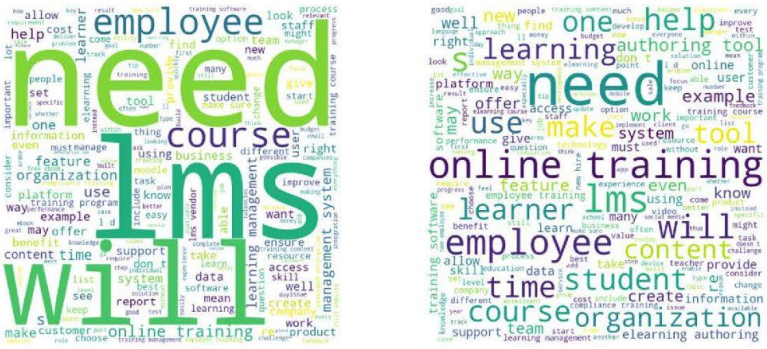


Figure 2. *Cont.*

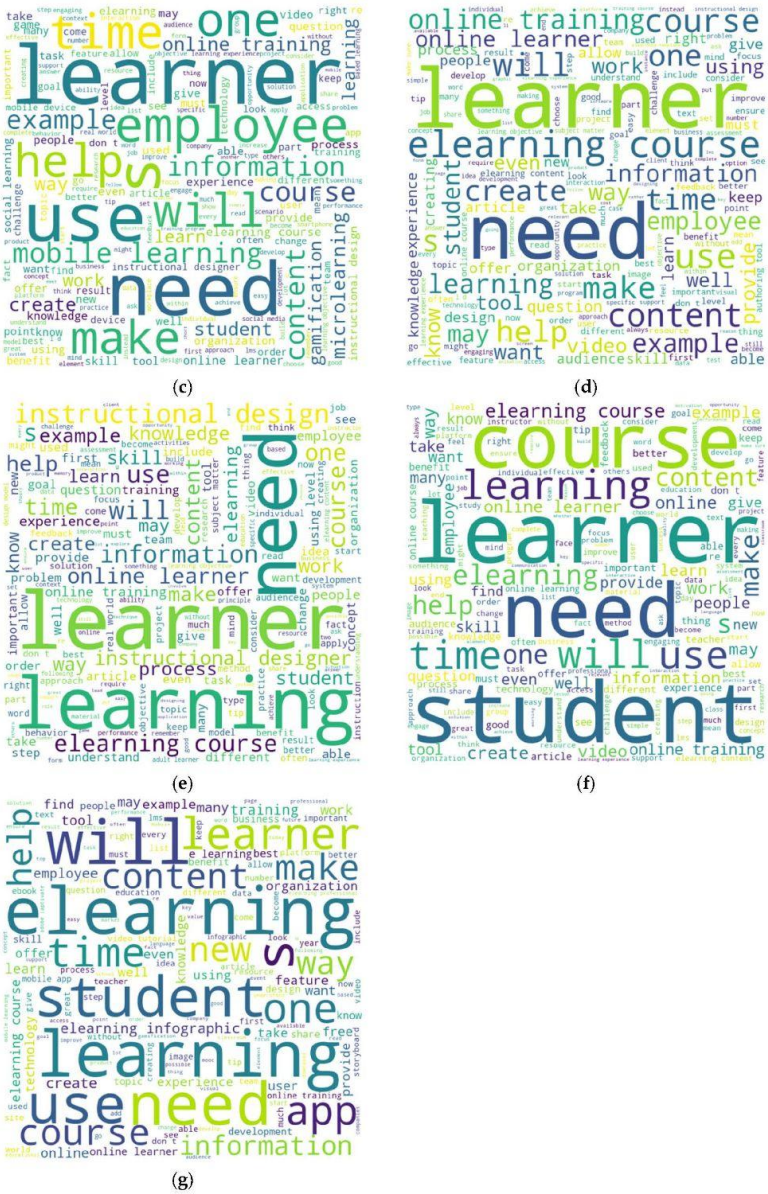


Figure 2. Most frequent words in each news category: (**a**) Learning Management System; (**b**) E-Learning Software (**c**) E-Learning Trends; (**d**) Design and Development; (**e**) Instructional Design; (**f**) Best Practices; (**g**) Free Resources.

4.1.3. N-Grams

In the Learning Management System category, the most frequent trigrams were related to using learning management systems for tracking and managing time, running a small business, and being easy to implement and maintain. In the E-Learning Software category, the most frequent trigrams were related to rapid prototyping, the implementation of platforms in corporate settings, and custom e-learning development materials. In the E-Learning Trends category, the trigrams described instructional design theories and models, responsive LMS solutions, and support for mobile learning. In the fourth category, Design and Development, the trigrams suggested rapid e-learning authoring tools and extending LMS functionality with JavaScript and HTML code snippets. In the Instructional Design category, the most frequent trigrams were associated with instructional design models, theories and history, the discussion of alternative instructional design models, and graduate certificates in instructional design. In the sixth category, Best Practices, the most frequently occurring trigrams were related to professional guides in instructional design practice. In the last category, Free Resources, the trigrams were related to e-learning and educational technology tool tutorials and free resources. Table 4 summarizes the trigrams and their frequencies in each news category.

Table 4. Top 10 trigram frequencies in each category.

News Category	Trigram	Frequency
Learning Management System	[*learning management system*]	1511
	[*online training course*]	407
	[*extended enterprise lms*]	313
	[*running a small business*]	293
	[*help free tool*]	291
	[*homebase help free*]	291
	[*manage team visit*]	291
	[*business never harder*]	291
	[*time manage team*]	291
	[*make work easier*]	291
E-Learning Software	[*elearning authoring tool*]	406
	[*learning management system*]	319
	[*online training course*]	283
	[*online training content*]	169
	[*online training software*]	163
	[*employee training software*]	163
	[*online training resource*]	104
	[*lms training company*]	94
	[*employee training participant*]	87
	[*value money lms*]	82
E-Learning Trends	[*learning management system*]	609
	[*online training course*]	319
	[*subject matter expert*]	255
	[*instructional design model*]	252
	[*mobile learning strategy*]	209
	[*online training resource*]	207
	[*mobile learning solution*]	192
	[*elearning authoring tool*]	189
	[*elearning course design*]	169
	[*online training program*]	147

Table 4. *Cont.*

News Category	Trigram	Frequency
Design and Development	[*learning management system*]	409
	[*online training course*]	381
	[*elearning authoring tool*]	336
	[*elearning course design*]	321
	[*subject matter expert*]	275
	[*online training resource*]	192
	[*elearning content development*]	181
	[*elearning content provider*]	169
	[*online training content*]	156
	[*online training program*]	119
Instructional Design	[*instructional design model*]	252
	[*subject matter expert*]	180
	[*online training course*]	132
	[*elearning course design*]	119
	[*design model theory*]	114
	[*learning management system*]	107
	[*learning battle card*]	85
	[*online learner able*]	71
	[*give online learner*]	69
	[*elearning authoring tool*]	61
Best Practices	[*learning management system*]	143
	[*online training resource*]	92
	[*elearning course design*]	90
	[*online training course*]	90
	[*elearning authoring tool*]	90
	[*subject matter expert*]	65
	[*online training content*]	55
	[*curated elearning content*]	50
	[*online training program*]	49
	[*elearning content curation*]	47
Free Resources	[*learning management system*]	49
	[*free video tutorial*]	36
	[*elearning course design*]	33
	[*elearning infographic template*]	29
	[*camstasia studio 8*]	28
	[*top elearning blog*]	27
	[*adobe captivate 7*]	22
	[*elearning authoring tool*]	21
	[*free moodle video*]	20
	[*mobile apps learning*]	18

4.2. RQ2: What Are the Characteristics of Sentiment, Named Entities, and Relationships among Entities in the Online Community?

4.2.1. Sentiment

The majority of online articles had a positive sentiment across all categories. However, a few articles had neutral and negative sentiments, in all news categories except the Learning Management System category. Table 5 summarizes the sentiment distributions for each news category.

Table 5. Sentiment distribution of articles.

News Category	Positive	Neutral	Negative	Total
Learning Management System	927	0	0	927
E-Learning Software	399	0	1	400
E-Learning Trends	2908	10	16	2934
Design and Development	2404	5	6	2415
Instructional Design	1061	0	4	1065
Best Practices	964	3	5	972
Free Resources	318	1	1	320
Total	8981	19	33	9033

4.2.2. Recognized Entities

After performing entity recognition with spaCy, the recognized entities emerged as pedagogical and educational technology entities. Figure 3 shows the distributions of the most frequent entities by news category. Based on the entities recognized, the following list ranks the news category in descending order:

1. Category 3: E-Learning Trends (58,606 entities);
2. Category 4: Design and Development (50,326 entities);
3. Category 1: Learning Management System (35,747 entities);
4. Category 5: Instructional Design (24,097 entities);
5. Category 6: Best Practices (18,944 entities);
6. Category 2: E-Learning Software (12,562 entities);
7. Category 7: Free Resources (6939 entities).

In first place, the most frequently recognized entities in the E-Learning Trends category were *eLearning* (9128), *LMS* (1809), *Instructional Design* (823), *L&D* (679), *Instructional Designers* (432), *mLearning* (256), *ADDIE* (206), *YouTube* (183), *Learning Management System* (173), *an Instructional Designer* (134), *Learning Management Systems* (119), and *Instructional Designer* (93). Regarding concepts, frameworks, theories, technologies, and practitioners, less frequent entities were found as follows: *xAPI* (40), *Bloom* (36), *Gardner* (24), *Pavlov* (29), *Hermann Ebbinghaus* (20), *Kirkpatrick* (19), *Connie Malamed* (16), *Michael Allen* (15), *Reusable Learning Objects* (14), *Knowles* (13), *Gagne* (11), and *Kolb* (10).

In second place, the most frequently recognized entities in the Design and Development category were *eLearning* (15,674), *LMS* (719), *L&D* (581), *PowerPoint* (258), *Instructional Design* (241), *eBook* (237), *Instructional Designers* (200), *Elucidat* (123), *YouTube* (110), *SCORM* (109), *HTML5* (98), and *Learning Management System* (89). Less frequent entities were identified among concepts, frameworks, technologies, and theories as follows: *Flash* (72), *ADDIE* (61), *Project Management* (55), *Camtasia* (51), *Bloom* (32), *Reusable Learning Objects* (28), and *Instructional Design* (20).

In third place, the most frequently recognized entities in the Learning Management System category were *LMS* (10,225), *eLearning* (1696), *Moodle* (466), *L&D* (462), *Learning Management System* (342), *Learning Management Systems* (246), *eCommerce* (123), *SME* (115), *a Learning Management System* (113), *CMS* (107), *eBook* (105), and *the Learning Management System* (91). Less frequent entities were Section 508 (2) and *WCAG 2.0* (2), referring to concepts, frameworks, and theories related to instructional design.

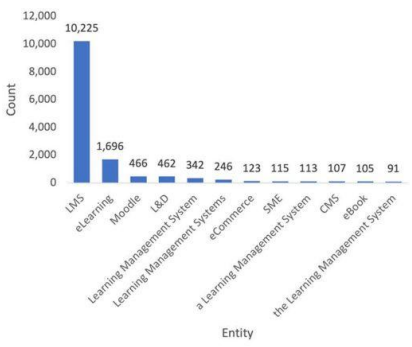
In fourth place, the most frequently recognized entities in the Instructional Design category were *eLearning* (4494), *Instructional Design* (760), *Instructional Designers* (337), *ADDIE* (200), *LMS* (165), *L&D* (161), *an Instructional Designer* (123), *eBook* (85), *the Instructional Designer* (83), *Instructional Designer* (82), *SME* (64), and *Design Thinking* (39). Less frequent entities in the Instructional Design category were related to models, concepts, and theories, including *SAM* (34), *Bloom* (32), *Project Management* (30), *Pavlov* (28), *Merrill* (26), *Malcolm Knowles* (17), *Sweller* (15), *Dick & Carey* (15), *Reusable Learning Objects* (14), *Skinner* (12), *Cognitive Apprenticeship Model* (12), *Howard Gardner* (11), *Herman Ebbinghaus* (11), *Vygotsky* (11), *Rapid Prototyping* (9), *Elaboration Theory* (4), *The Agile Manifesto* (3), *Cognitive Load Theory* (3), *The Spiral Model* (3), *T-Shaped Learning Design Interest Approach* (2), *Nine Events of*

Instruction (2), *ARCS model of Motivation* (2), *Collaborative Learning Approach* (2), *Discovery Learning Model* (2), *AGES Model* (2), and *Basic Action Workflow* (2).

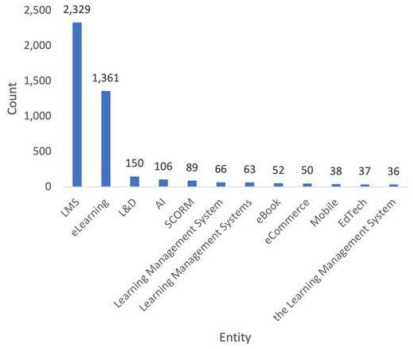
In fifth place, the most frequently recognized entities in the Best Practices category were *eLearning* (4717), *LMS* (409), *PowerPoint* (89), *L&D* (80), *Instructional Design* (67), *YouTube* (60), *Instructional Designers* (56), *eBook* (48), *Learning Management System* (40), *Elucidat* (37), *eLearners* (34), and *PDF* (32). Regarding models, concepts, and theories, less frequent entities were identified, as follows: *Principles of Effective Online Pedagogy* (2), *The Importance Of Meaningful Online Feedback* (2), *Active Learning* (2), *Bernard* (2), *Instructional Design Model* (1), Section 508 (1), and *American Disabilities Act* (1).

In sixth place, the most frequently recognized entities in the E-Learning Software category were *LMS* (2329), *eLearning* (1361), *L&D* (150), *AI* (106), *SCORM* (89), *Learning Management System* (66), *Learning Management Systems* (63), *eBook* (52), *eCommerce* (50), *Mobile* (38), *EdTech* (37), and *the Learning Management System* (36). Less frequent entities in this category involved *JIT* (just in time, 33), *LXP* (learning experience platform, 21), *eBooks* (17), *ADDIE Model* (1), Section 508 (3), *Universal Design for Learning* (1), and *Learning Methods* (1). The ebooks were related to corporate training, new employee onboarding, and the branding of online courses.

In seventh place, the most frequently recognized entities in the Free Resources category were *eLearning* (1414), *LMS* (119), *eBook* (63), *L&D* (59), *Adobe Captivate* (26), *Instructional Design* (25), *PowerPoint* (24), *eLearning Infographics* (23), *eLearning Industry* (22), *Mobile* (21), *Camtasia* (21), and *Learning Management Systems* (19). In this particular category, less frequent entities were *Docebo* (16), *eBooks* (15), *Adobe Captivate* (14), *Blackboard* (8), *Camtasia Studio* (7), *Vidopop* (7), *Kallidus* (6), *Snagit* (6), *Docebo* (5), and *Nine Events of Instruction* (1). In this category, the ebooks offered different topics related to managing learning objects, vendors for learning technologies, free infographic tools, and how to become an instructional designer.



(**a**)



(**b**)

Figure 3. *Cont.*

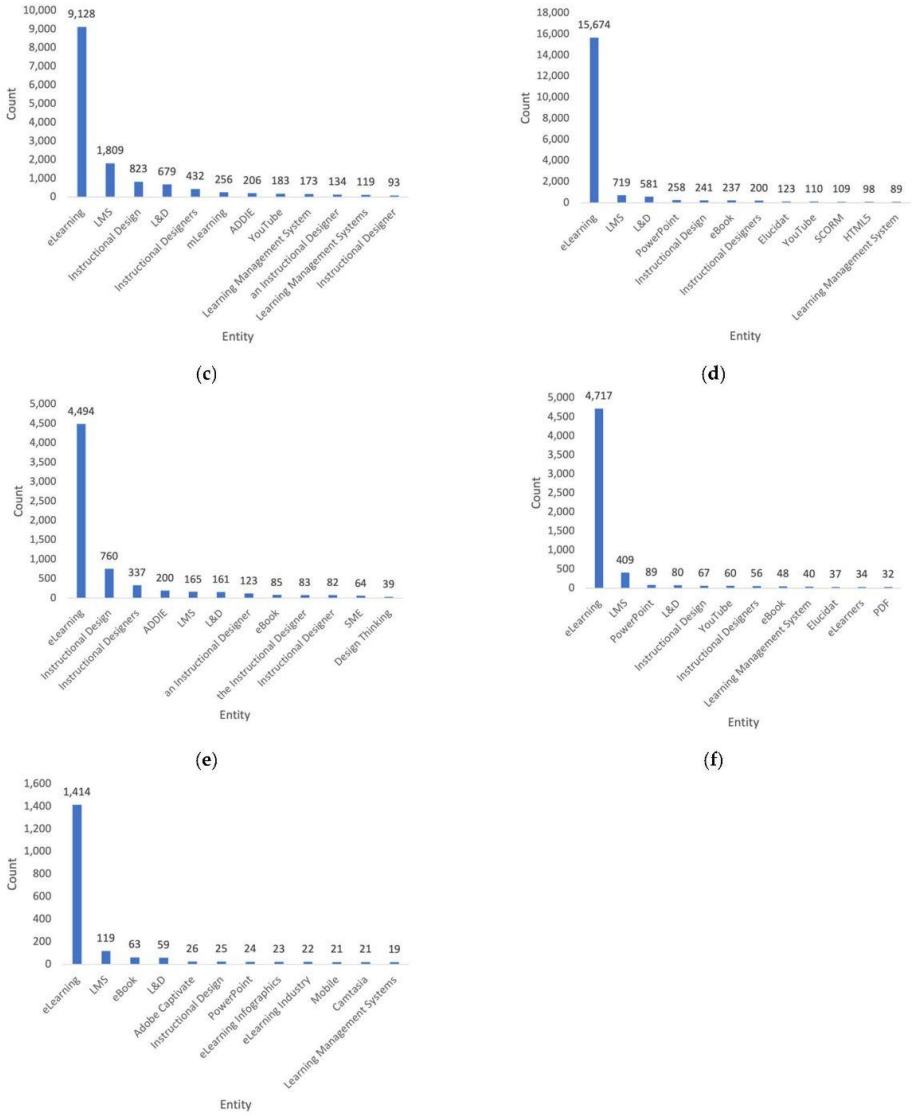


Figure 3. Most recognized entities in each news category: (**a**) Learning Management System; (**b**) E-Learning Software (**c**) E-Learning Trends; (**d**) Design and Development; (**e**) Instructional Design; (**f**) Best Practices; (**g**) Free Resources.

4.2.3. Entity Relationships

Prominent relationships between entities were extracted when community members used specific words to describe pedagogical and educational technology entities. The words used to define the relationships between entities identified how the community described the context of pedagogical and educational technology elements in the online articles. Table 6 summarizes the 10 most frequent entity relationships for each news category. Based on the entity relationships recognized, the following list ranks the news categories in descending order:

1. Category 3: E-Learning Trends (1326 entity relationships);
2. Category 4: Design and Development (1174 entity relationships);
3. Category 6: Best Practices (626 entity relationships);
4. Category 5: Instructional Design (611 entity relationships);
5. Category 2: E-Learning Software (300 entity relationships);
6. Category 7: Free Resources (236 entity relationships);
7. Category 1: Learning Management System (213 entity relationships).

In first place, the E-Learning Trends category had 1326 entity relationships that demonstrated the ease of use of learning management systems (e.g., Talent LMS, Administrate) for deploying online courses aimed at users with zero experience, using simple interfaces. In second place, the Design and Development category identified 1174 entity relationships that emphasized strategies and tips for developing effective e-learning (e.g., learner engagement and motivation strategies), the formative assessment of online courses, and free media resources.

In third place, the Best Practices category contained 626 entity relationships that suggested project management strategies for e-learning development, instructional strategies (e.g., gamification and avatars), effective feedback to learners, and the creation of high-quality images. In fourth place, the Instructional Design category had 611 entity relationships that suggested creating memorable e-learning experiences and incorporating learning theories in e-learning development (e.g., cognitive load multimedia learning, adult learning, active learning, and Ebbinghaus' forgetting curve).

In fifth place, the E-Learning Software category identified 300 entity relationships that suggested several aspects of learning management systems for training, reporting, aligning e-learning materials with business goals, and licensing software options. In sixth place, the Free Resources category contained 236 entity relationships that offered free Web 2.0 resources, free stock photo libraries, and webinar and conference resources. In seventh place, the Learning Management System category had 213 entity relationships, including reviews of learning management systems (e.g., Talent LMS, ShareKowledge, Administrate), administrative and learner features, and implementation costs for organizations.

Table 6. Top 10 most frequent entity relationships and frequencies by news category.

News Category	Entity	Frequency
Learning Management System	*website*	509
	read	67
	published	35
	want	14
	captivate prime	12
	means	8
	features	6
	allow	5
	help	5
	take free	5

Table 6. *Cont.*

News Category	Entity	Frequency
E-Learning Software	*studio*	8
	references	6
	costs	5
	use	4
	features	4
	take	4
	conclusion	4
	need	3
	help	3
	halfpoint	2
E-Learning Trends	*read*	77
	need	25
	used	24
	want	22
	check	21
	use	21
	help	21
	leave	20
	studio	20
	find	18
Design and Development	*read*	107
	use	33
	help	27
	find	23
	take	20
	make	19
	create	18
	need	15
	professional	15
	keep	15
Instructional Design	*read*	41
	leave	12
	used	11
	think	9
	check	9
	find	9
	images	8
	offer instructional	8
	know	7
	learning	7
Best Practices	*read*	35
	use	13
	images	12
	help	11
	make	10
	want	8
	studio	8
	learn	7
	let	7
	find	7

Table 6. *Cont.*

News Category	Entity	Frequency
Free Resources	*join free*	6
	use	5
	visit	5
	find	4
	help	4
	read	4
	missed free	4
	captivate	4
	see	4
	want	3

4.3. RQ3: What Are the Latent Topic Structures in the Online Community?

Across all news categories, the BoW topic models had better topic interpretation than the TF-IDF models, based on the subject matter and higher probabilities of topic distributions. The BoW and sentence transformer topic models are described below by news category.

4.3.1. Category 1: Learning Management System

In the topic models using the BoW and sentence transformers, the Learning Management System category showed seven emerging topics related to custom training development, platform implementation costs and experiences, and the various uses of platforms for employee onboarding, online compliance training, and user and content management. Table 7 summarizes the BoW and sentence transformer topic models for the category.

Table 7. Emerging topic patterns for the Learning Management System category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	Employee Onboarding	Employee Training
Topic 2	Custom Online Training	Online Compliance Training
Topic 3	LMS Requirements	LMS User and Content Management
Topic 4	Online Compliance Training	LMS Implementation
Topic 5	LMS Implementation	Employee Training
Topic 6	Employee Training	LMS Implementation
Topic 7	LMS User and Content Management	Online Employee Training Costs

4.3.2. Category 2: E-Learning Software

In the BoW topic model, four topics were related to the various uses of e-learning development for employee onboarding, language acquisition courses, online compliance training, and e-learning software reviews. In the sentence transformer topic model, eight topic models were associated with platform use in various settings (e.g., K-12 and corporate), organizational goals (e.g., compliance and education), mobile learning support, user and content management, and platform requirements. Table 8 summarizes the BoW and sentence transformer topic models for the category.

Table 8. Emerging topic patterns for the E-Learning Software category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	Language Courses	LMS Requirements
Topic 2	Employee Onboarding	Employee Onboarding
Topic 3	Online Compliance Training	Technology in Educational Settings
Topic 4	E-Learning Authoring Tools	LMS in Corporate Settings
Topic 5		Technology in Educational Settings
Topic 6		LMS User and Content Management
Topic 7		Mobile Learning
Topic 8		E-Learning Authoring Tools

4.3.3. Category 3: E-Learning Trends

In the BoW topic model, three topic models described gamification, e-learning development, and mobile learning. Interestingly, the sentence transformer topic model generated 27 emerging topics. Five topics displayed the highest probability, including the instructional design process, microlearning, new employee onboarding, social media for collaboration and networking, and learning theories. Table 9 summarizes the BoW and sentence transformer topic models for the category.

Table 9. Emerging topic patterns for the E-Learning Trends category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	Gamification	Instructional Design Process
Topic 2	E-Learning Development	Microlearning
Topic 3	Mobile Learning	Collaboration and Networking
Topic 4		Employee Onboarding
Topic 5		Learning Theories

4.3.4. Category 4: Design and Development

In the BoW topic model, nine emerging topics were related to the assessment and various processes of e-learning and employee training development, including mobile learning, e-learning templates, e-learning examples, engagement strategies, the translation of courses, and voiceover recording. The sentence transformer topic model showed six topics related to educational animation, learning objectives development, the translation of courses, learning theories, assessment, and voiceover recording. Table 10 summarizes the BoW and sentence transformer topic models for the category.

Table 10. Emerging topic patterns for the Design and Development category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	Mobile Learning	Educational Animation
Topic 2	E-Learning Development	Course Translation
Topic 3	E-Learning Templates	Assessment
Topic 4	Employee Training	Voiceover
Topic 5	Voiceover	Learning Theories
Topic 6	E-Learning Examples	Learning Objectives
Topic 7	Engaging E-Learning	
Topic 8	Course Translation	
Topic 9	Assessment	

4.3.5. Category 5: Instructional Design

In the BoW topic model, two out of five similar topics were related to e-learning development, whereas the remainder were related to estimating time for e-learning development, employee training, and learning theories. The sentence transformer topic model generated 11 topics. Only six contained the highest probabilities, including e-learning development, learning theories, adult learning, instructional video development, user interface design, and instructional design jobs. Table 11 summarizes the BoW and sentence transformer topic models for the category.

Table 11. Emerging topic patterns for the Instructional Design category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	Estimate Development Time	E-Learning Development
Topic 2	Employee Training	Learning Theories
Topic 3	E-Learning Development	Adult Learning
Topic 4	E-Learning Development	Video Development
Topic 5	Learning Theories	User Interface Design
Topic 6		Instructional Design Jobs

4.3.6. Category 6: Best Practices

The BoW topic model described three emerging topics, with two similar topics relating to e-learning development, and one topic related to the translation of courses. In the sentence transformer topic model, four topics contained online learning, the development of language courses, student feedback, and instructional video development. Table 12 summarizes the BoW and sentence transformer topic models for the category.

Table 12. Emerging topic patterns for the Best Practices category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	E-Learning Development	Online Learning
Topic 2	Course Translation	Language Courses
Topic 3	E-Learning Development	Student Feedback
Topic 4		Video Development

4.3.7. Category 7: Free Resources

The BoW topic model showed 10 emerging topics related to different aspects of e-learning development (e.g., image and video editing, storyboarding), online resources (e.g., online webinars, image resources, and professional development opportunities), and e-learning authoring tips (e.g., Adobe Captivate and Camtasia). In the sentence transformer topic model, four emerging topics described online training resources, tips for e-learning authoring tools, e-learning development resources, and mobile apps. Table 13 summarizes the BoW and sentence transformer topic models for the category.

Table 13. Emerging topic patterns for the Free Resources category.

Topic	Bag-of-Words	Sentence Transformers
Topic 1	Multimedia Resources	Training Resources
Topic 2	Video Development	Adobe and Camtasia
Topic 3	Adobe Captivate	Infographic Resources
Topic 4	Employee Training	Apps
Topic 5	Storyboarding	
Topic 6	Professional Development	
Topic 7	Infographics	
Topic 8	Webinars	
Topic 9	Multimedia Resources	
Topic 10	Multimedia Resources	

5. Discussion

CMSs facilitate the creation and dissemination of knowledge. As a blog-publishing platform, the e-learning news outlet acts as a crowdsourcing mechanism for producing and managing online articles. The online articles from this CoP offer practitioners informal learning opportunities with easy-to-read online articles. Online articles in the Free Resources category had the shortest average word count of 523.19. In contrast, online articles in the Learning Management System and E-Learning Software categories had the highest average word counts of 1214.37 and 946, respectively. Online articles in the five remaining news categories had an average word count between 523.19 and 690.35. Although online articles in the Learning Management System and E-Learning Software categories were longer, this community of practice may require the writing of persuasive online articles to support educational technology vendors and recommendations. As Chambliss and Garner [39] stated, crafting convincing messaging requires three essential pieces, including the evidence, claim, and warrant, in order to sustain persuasive written communication in support of the author's arguments and lead to changed beliefs.

Though practitioners can submit online articles, the site did not describe the editing and review processes behind selecting credible sources of information. Interestingly, the

sentiment distribution of online articles indicated that most articles across the categories were positive. Only a few online articles had neutral and negative sentiments across six news categories, except the Learning Management System category. Positive online articles may be written persuasively to convince instructional designers and e-learning developers to adopt certain pedagogical practices and educational technology tools. Chambliss and Garner [39] argued that readers could change their beliefs while reading a persuasive text. Still, readers tended to revert to old ideas consistent with past experiences and background knowledge.

Regarding e-learning, this IDT community may have carefully crafted online articles in a positive tone that attract newly minted and accidental practitioners who are more willing to accept pedagogical and technical advice than experienced practitioners. Acevedo and Roque [63] argued that the instructional design field is at risk of deprofessionalization, resulting in non-experts becoming practitioners who prioritize online courseware production over learning theory, instructional design models, and pedagogy. Non-experts are practitioners who landed in instructional design and e-learning development roles, with the job of training others in the organization, without formal training [64]. While the E-Learning Industry site emphasizes the production of e-learning materials in their online articles, this CoP needs to associate technology-related articles with the instructional design news category. This way, practitioners of different professional backgrounds have the necessary pedagogical foundations to support technology-enabled learning environments and combat misconceptions about learning (e.g., learning styles).

5.1. Priorities of the Online CoP

The knowledge-production capability of this IDT community showcases the sense of responsibility (i.e., professional agency) to practitioners who access the site's resources by offering recommendations, evaluations, and reports that support the pedagogical and educational technology aspects of instructional design practice. The word frequencies emphasized learning management systems as a critical medium for managing and delivering e-learning courses to learners, students, or employees for online onboarding, skill development, and compliance reasons. The findings also suggested that the words *need*, *lms*, and *learner* were present across the seven categories with various degrees of frequency.

By observing the trigrams generated from each category, the findings point out the priorities of this online community. The use of learning management systems and online training courses was present across the seven news categories. Furthermore, the trigrams in the Learning Management System category showed the alternative uses of platforms for running e-learning shops as small businesses and managing e-learning development time. The trigrams in the E-Learning Software category emphasized the rapid development of online experiences, the integration of courses in learning management systems, and implementation costs. The trigrams in the E-Learning Trends category were characterized by authoring online training courses or training for mobile devices. The trigrams in the Instructional Design category were related to instructional design models, working with subject matter experts, e-learning course design processes, and gamified tools (e.g., learning battle cards) for learning instructional design and e-learning. The trigrams in the Best Practices category had a mix of overlapping trigrams from the first five news categories. The trigrams in the Free Resources category involved tutorials and templates to support practitioners with e-learning authoring tools (e.g., Camtasia, Captivate, and Moodle) and mobile apps.

Furthermore, the most frequently recognized entities were *eLearning*, *LMS*, and *L&D* (Learning and Development) across the seven categories. The predominant entity relationships were found in educational technology tools and e-learning platforms. The word *read* was the most common entity that tied educational technology and pedagogical entities across all categories, except the E-Learning Software and Free Resources categories. The entity relationships for *read* suggested that the authors of the articles tended to make refer-

ences to existing materials in the community or pointed to external resources (e.g., blog posts, research articles, and vendors).

5.2. E-Learning Materials Production as the Purpose of the Community

Based on the findings, the topic models suggested emphasizing the production of e-learning materials as the main purpose of the online community. In the Learning Management and E-Learning Software categories, most topic structures suggested the use of cases involved in training and the implementation of learning management systems and the authoring of online courses on platforms. In the E-Learning Trends category, topic models suggested a few instructional strategies, including gamification, social learning, and mobile learning. In the Design and Development category, the topic models emphasized e-learning development templates for online training, interactivity in e-learning (e.g., voice-over and animation), and the assessment of learners. In the Instructional Design category, most topic models were similar to those of the Design and Development category. A few topics in instructional design theories and user interface design were also present in the Instructional Design category. In the Best Practices category, the topic models were closely related to the Learning Management System and Design and Development categories. The Free Resources category had the highest number of topic models related to resources that support specific technical aspects of e-learning development.

5.3. Implications for Research and Practice

The results of the study have implications for researchers, practitioners, and leaders of online communities of practice. The findings of this study highlight the need to understand how professional competencies align with the community's practical knowledge based on the discovered topic models and pedagogical and educational technology entities. Further investigation of how practical knowledge in e-learning materials production is applied or transferred to practitioners' work contexts is required. Besides studying the learning transfer of informal learning opportunities, the quality of practical knowledge from the community needs to be further investigated to understand the inner workings and dynamics of the community's knowledge-production capabilities.

The findings suggest the need for practitioners to better understand how their self-conscious learning efforts integrate with their existing knowledge, skills, and abilities. Though this community is focused on the technical aspects of the production of e-learning materials, practitioners need to self-assess their personal knowledge-management capabilities to explore the required tacit cognitive knowledge (e.g., learning theories) required for integrating learning experiences in technology-enabled settings. The findings were mainly in line with those of North et al. [65]. The researchers showed that job postings in instructional design emphasized online training technology application and production. In contrast, capabilities in knowledge management, lifelong learning, and business insight received less attention.

As practitioners seek informal learning opportunities, leaders of online communities of practice can benefit from the findings by understanding the current capabilities for producing and sharing knowledge. Furthermore, leaders of these communities can assess their current organizational knowledge and competencies to provide additional informal learning opportunities in the learning sciences. Community leaders can also use the findings to develop mechanisms for improving the navigation and alignment of produced knowledge for instructional design competencies. In return, practitioners can evaluate their knowledge, skills, and abilities against the expectations and competencies of the profession.

5.4. Recommendations

Though the representation of practical knowledge was modeled using NLP, the inner workings of how the community selects and reviews online articles could not be observed. Four recommendations are necessary to sustain online communities and promote member

participation by increasing transparency, aligning with competencies, reusing knowledge, and establishing clear boundaries.

While practitioners can submit online articles to the online community, the first recommendation is to make submission and review requirements visible in the community by establishing a rubric to control contribution quality. The second recommendation involves providing members with mechanisms to align online articles with instructional design competencies. By providing such mechanisms, members are better positioned to self-assess knowledge, skills, and abilities. Due to the wealth of resources across several news categories, the third recommendation is to allow community members to browse related content across news categories. While the organizational scheme is useful for organizing online articles, members should be able to cross-check information across the categories to understand the different aspects of the profession. For example, when reviewing online articles related to the production of e-learning materials, members are presented with related content on how to support learner engagement and assessment. The fourth recommendation is to establish clear boundaries that reject self-serving online articles that deter productive participation, and that genuinely advance the field of instructional design. At the same time, community members can observe how the community behaves with integrity, especially new members participating on the periphery.

5.5. Limitations

The present study was not without limitations. While online articles contained videos and links to external resources, these online artifacts were not analyzed because they were hosted outside of the online community. Additionally, e-books and guides created by the community were not analyzed because these were referenced in the Free Resources category. Additionally, users' comments on articles were not extracted because these were not present across all online articles. A significant amount of tacit knowledge was contained in these external resources, but they were not analyzed due to time constraints and the additional processing time required to model additional data.

6. Conclusions

This study aimed to identify the tacit knowledge from an e-learning news outlet called elearningindustry.com. Practitioners were invited to write online articles under multiple categories. The E-Learning news outlet relies on a CMS where online articles are deployed under different categories and approved by community administrators. By examining the codified, or explicit knowledge, from online news articles, the study aimed to quantify the organizational knowledge capital of the community, the types of tacit knowledge, and the hidden topic structures present in each news category. The quantification of practical knowledge shows the knowledge-creation capabilities and priorities of this CoP. The findings suggest that most topics were related to tacit technical knowledge of the production of e-learning materials. Though tacit technical knowledge was prevalent, tacit cognitive knowledge was present to a lesser degree. The findings provide evidence of the types of practical knowledge that practitioners may use for their informal learning endeavors across several industries. The results offer topic-organization schemes to leaders of CoPs, in order to enhance practitioners' abilities to self-assess and organize their practical knowledge.

The future direction of this research involves an investigation of the emerging patterns of practical knowledge by the type of sentiment, in order to uncover the challenging aspects of instructional practice. Additionally, the findings of this study enable the future development of ontologies and taxonomies to classify types of practical knowledge (i.e., cognitive and technical) and make distinctions between pedagogical and educational technology entities, which can be applied to assess the practical knowledge present in other online CoPs.

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References

1. Yanchar, S.C.; Hawkley, M.N. Instructional design and professional informal learning: Practices, tensions, and ironies. *J. Educ. Technol. Soc.* **2015**, *18*, 424–434.
2. Clinton, G.; Rieber, L.P. The Studio experience at the University of Georgia: An example of constructionist learning for adults. *Educ. Technol. Res. Dev.* **2010**, *58*, 755–780. [CrossRef]
3. Ertmer, P.A.; Stepich, D.A.; York, C.S.; Stickman, A.; Wu, X.; Zurek, S.; Goktas, Y. How instructional design experts use knowledge and experience to solve ill-structured problems. *Perform. Improv. Q.* **2008**, *21*, 17–42. [CrossRef]
4. Hardré, P.L.; Ge, X.; Thomas, M.K. An Investigation of Development Toward Instructional Design Expertise. *Perform. Improv. Q.* **2008**, *19*, 63–90. [CrossRef]
5. Lim, D.H.; You, J.; Kim, J.; Hwang, J. Instructional design for adult and continuing higher education: Theoretical and practical considerations. *Res. Anthol. Adult Educ. Dev. Lifelong Learn.* **2021**, 1018–1038. [CrossRef]
6. García-Peñalvo, F.J. Informal Learning Management Experiences. *Int. J. Hum. Cap. Inf. Technol. Prof.* **2014**, *5*, iv–ix.
7. Önday, Ö. Web 6.0: Journey from Web 1.0 to Web 6.0. *J. Media Manag.* **2019**, *1*, 1–6. [CrossRef]
8. Martinez, S.; Whiting, J. Designing Informal Learning Environments. In *Design for Learning: Principles, Processes, and Praxis*; McDonald, J.K., West, R.E., Eds.; EdTech Books: Online, 2021; Available online: https://edtechbooks.org/id/designing_informal (accessed on 6 March 2022).
9. Abramenka-Lachheb, V.; Lachheb, A.; Leung, J.; Sankaranarayanan, R.; Seo, G.Z. Instructional Designers' Use of Informal Learning: How Can We All Support Each Other in Times of Crisis? *J. Appl. Instr. Des.* **2021**, *10*. [CrossRef]
10. Conlon, T.J. A review of informal learning literature, theory and implications for practice in developing global professional competence. *J. Eur. Ind. Train.* **2004**, *28*, 283–295. [CrossRef]
11. Evans, J.R.; Karlsven, M.; Perry, S.B. Informal Learning. In *The Students' Guide to Learning Design and Research*; Kimmons, R., Ed.; EdTech Books: Online, 2018; Available online: https://edtechbooks.org/studentguide/informal_learning (accessed on 20 March 2022).
12. Detect which CMS a Site is Using-What CMS? What CMS Is This Site Using? Available online: https://whatcms.org/?s=elearningindustry.com (accessed on 18 March 2022).
13. elearning Industry Inc. About. Elearning Industry. Available online: https://elearningindustry.com/about-us (accessed on 18 March 2022).
14. ICANN. Registration Data Lookup Tool. Available online: http://maintenance.icann.org/lookup (accessed on 18 March 2022).
15. Similarweb. Available online: https://www.similarweb.com/ (accessed on 28 February 2022).
16. Nonaka, I.; Takeuchi, H. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*; Oxford University Press: Oxford, UK, 1995.
17. Wenger, E. Communities of practice: Learning as a social system. *Syst. Think.* **1998**, *9*, 2–3. [CrossRef]
18. Wenger, E.C.; Snyder, W.M. Communities of practice: The organizational frontier. *Harv. Bus. Rev.* **2000**, *78*, 139–146.
19. Gray, B. Informal learning in an online community of practice. *Int. J. E-Learn. Distance Educ./La Revue Internationale de l'Apprentissage en Ligne et de l'Enseignment À Distance* **2004**, *19*, 20–35.
20. Schwier, R.A.; Campbell, K.; Kenny, R. Instructional designers' observations about identity, communities of practice and change agency. *Australas. J. Educ. Technol.* **2004**, *20*. [CrossRef]
21. Schwier, R.A.; Campbell, K.; Kenny, R.F. Instructional designers' perceptions of their agency: Tales of change and community. In *Instructional Design: Case Studies in Communities of Practice*; IGI Global: Hershey, PA, USA, 2007; pp. 1–18.
22. Access the Capability Model. American Talent Development. Available online: https://www.td.org/capability-model/access (accessed on 5 August 2021).
23. Instructional Designer Competencies. Welcome to Ibstpi. 21 April 2016. Available online: https://ibstpi.org/instructional-design-competencies/ (accessed on 18 March 2022).
24. Martin, F.; Ritzhaupt, A.D. Standards and Competencies for Instructional Design and Technology Professionals [E-book]. In *Design for Learning*; 2020; p. 20. Available online: https://edtechbooks.org/id/standards_and_competencies (accessed on 21 April 2022).
25. ISTE Standards: Educators | ISTE. ISTE Standards: Educators. Available online: https://www.iste.org/standards/iste-standards-for-teachers (accessed on 10 March 2022).
26. Polanyi, M. *The Tacit Dimension*, 2009th ed.; The University of Chicago Press: Chicago, IL, USA, 1966.
27. Wagner, R.K.; Sternberg, R.J. Practical intelligence in real-world pursuits: The role of tacit knowledge. *J. Personal. Soc. Psychol.* **1985**, *49*, 436. [CrossRef]
28. McAdam, R.; Mason, B.; McCrory, J. Exploring the dichotomies within the tacit knowledge literature: Towards a process of tacit knowing in organizations. *J. Knowl. Manag.* **2007**, *11*, 43–59. [CrossRef]

29. Viale, R.; Pozzali, A. Cognitive Aspects of Tacit Knowledge and Cultural Diversity. *Model-Based Reason. Sci. Technol. Med.* **2007**, *64*, 229–244. [CrossRef]
30. Steiger, D.M.; Steiger, N.M. Instance-based cognitive mapping: A process for discovering a knowledge worker's tacit mental model. *Knowl. Manag. Res. Pract.* **2008**, *6*, 312–321. [CrossRef]
31. Johnson-Laird, P.; Byrne, R. Mental models website: A gentle introduction. *Recuper. El* **2000**, *22*. Available online: http://www.tcd.ie/Psychology/Ruth_Byrne/mental_models/index.html (accessed on 21 April 2022).
32. Bolade, S.; Sindakis, S. Micro-Foundation of Knowledge Creation Theory: Development of a Conceptual Framework Theory. *J. Knowl. Econ.* **2019**, *11*, 1556–1572. [CrossRef]
33. Chen, C.-H.; Saeedi, M. Building a Trust Model in the Online Market Place. *J. Internet Commer.* **2006**, *5*, 101–115. [CrossRef]
34. Dudek, A.; Patalas-Maliszewska, J. A Model of a Tacit Knowledge Transformation for the Service Department in a Manufacturing Company: A Case Study. *Found. Manag.* **2016**, *8*, 175–188. [CrossRef]
35. Jackson, T.W.; Tedmori, S.; Hinde, C.J.; Bani-Hani, A. The Boundaries of Natural Language Processing Techniques in Extracting Knowledge from Emails. *J. Emerg. Technol. Web Intell.* **2012**, *4*, 119–127. [CrossRef]
36. Mohanan, M.; Samuel, P. Software Requirement Elicitation Using Natural Language Processing. In *Innovations in Bio-Inspired Computing and Applications*; Springer: Cham, Switzerland, 2015; pp. 197–208. [CrossRef]
37. Satsangi, P. Automation of Tacit Knowledge Using Machine Learning. In Proceedings of the 2019 6th International Conference on Soft Computing & Machine Intelligence (ISCMI), Johannesburg, South Africa, 19–20 November 2019; pp. 35–39.
38. Stone, A.; Sawyer, P. Identifying tacit knowledge-based requirements. *IEE Proc. Softw.* **2006**, *153*, 211–218. [CrossRef]
39. Chambliss, M.J.; Garner, R. Do Adults Change their Minds after Reading Persuasive Text? *Writ. Commun.* **1996**, *13*, 291–313. [CrossRef]
40. Srivastav, A.; Singh, S. Proposed Model for Context Topic Identification of English and Hindi News Article Through LDA Approach with NLP Technique. *J. Inst. Eng. Ser. B* **2021**, *103*, 591–597. [CrossRef]
41. Shang, X.; Peng, Z.; Yuan, Q.; Khan, S.; Xie, L.; Fang, Y.; Vincent, S. DIANES: A DEI Audit Toolkit for News Sources. *arXiv* **2022**, arXiv:2203.11383.
42. Fung, Y.C.; Lee, L.K.; Chui, K.T.; Cheung, G.H.K.; Tang, C.H.; Wong, S.M. Sentiment Analysis and Summarization of Facebook Posts on News Media. In *Data Mining Approaches for Big Data and Sentiment Analysis in Social Media*; IGI Global: Hershey, PA, USA, 2022; pp. 142–154.
43. Singh, R.; Singh, S. Text Similarity Measures in News Articles by Vector Space Model Using NLP. *J. Inst. Eng. Ser. B* **2020**, *102*, 329–338. [CrossRef]
44. Yu, S.; Martino, G.D.S.; Nakov, P. Experiments in detecting persuasion techniques in the news. *arXiv* **2019**, arXiv:1911.06815.
45. Gao, N.; Touran, A.; Wang, Q. Mining and Visualizing Cost and Schedule Risks from News Articles with NLP and Network Analysis. *Constr. Res. Congr.* **2022**, 314–324. [CrossRef]
46. Jaidka, K.; Ceolin, A.; Singh, I.; Chhaya, N.; Ungar, L. WikiTalkEdit: A Dataset for modeling Editors' behaviors on Wikipedia. In Proceedings of the 2021 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Online, 6–11 June 2021; pp. 2191–2200.
47. Brugman, S. Introduction—Pandas-Profiling 3.0.0 Documentation. Pandas Profiling. 2021. Available online: https://pandas-profiling.github.io/pandas-profiling/docs/master/rtd/ (accessed on 6 August 2021).
48. Mueller, A. WordCloud for Python Documentation—Wordcloud 1.8.1 Documentation. WordCloud for Python. 2020. Available online: http://amueller.github.io/word_cloud/ (accessed on 6 March 2021).
49. Kaur, J.; Buttar, P.K. A systematic review on stopword removal algorithms. *Int. J. Future Revolut. Comput. Sci. Commun. Eng.* **2018**, *4*, 207–210.
50. Gerlach, M.; Shi, H.; Amaral, L.A.N. A universal information theoretic approach to the identification of stopwords. *Nat. Mach. Intell.* **2019**, *1*, 606–612. [CrossRef]
51. Natural Language Toolkit—NLTK 3.6.2 Documentation. Natural Language Processing Toolkit-NLTK. Available online: https://www.nltk.org/ (accessed on 6 August 2021).
52. Lorian, S. TextBlob: Simplified Text Processing—TextBlob 0.16.0 documentation. TextBlob: Simplified Text Processing. Available online: https://textblob.readthedocs.io/en/dev/ (accessed on 6 August 2021).
53. spaCy. Industrial-strength Natural Language Processing in Python. spaCy-Industrial-Strength Natural Language Processing. Available online: https://spacy.io/ (accessed on 6 August 2021).
54. Řehůřek, R. Gensim: Topic Modelling for Humans. 2009. Available online: https://radimrehurek.com/gensim/ (accessed on 6 August 2021).
55. Grootendorst, M. GitHub-MaartenGr/BERTopic: Leveraging BERT and c-TF-IDF to Create Easily Interpretable Topics. BERTopic. 2020. Available online: https://github.com/MaartenGr/BERTopic (accessed on 18 March 2022).
56. Reimers, N. Pretrained Models—Sentence-Transformers Documentation. Pre-Trained Models. 2021. Available online: https://www.sbert.net/docs/pretrained_models.html (accessed on 6 August 2021).
57. Chang, J.; Gerrish, S.; Wang, C.; Boyd-Graber, J.; Blei, D. Reading tea leaves: How humans interpret topic models. In Proceedings of the Advances in Neural Information Processing Systems, Vancouver, BC, Canada, 7–10 December 2009; Volume 22.
58. Rosner, F.; Hinneburg, A.; Röder, M.; Nettling, M.; Both, A. Evaluating topic coherence measures. *arXiv* **2014**, arXiv:1403.6397.

59. Krotov, V.; Murray State University; Johnson, L.; Silva, L. University of Houston Legality and Ethics of Web Scraping. *Commun. Assoc. Inf. Syst.* **2020**, *47*, 539–563. [CrossRef]
60. Mancosu, M.; Vegetti, F. What You Can Scrape and What Is Right to Scrape: A Proposal for a Tool to Collect Public Facebook Data. *Soc. Media Soc.* **2020**, *6*. [CrossRef]
61. Catanese, S.A.; De Meo, P.; Ferrara, E.; Fiumara, G.; Provetti, A. Crawling facebook for social network analysis purposes. In Proceedings of the international conference on web intelligence, mining and semantics, Sogndal, Norway, 25–27 May 2011; pp. 1–8.
62. Washburn, A.N.; Hanson, B.E.; Motyl, M.; Skitka, L.J.; Yantis, C.; Wong, K.M.; Sun, J.; Prims, J.P.; Mueller, A.B.; Melton, Z.J.; et al. Why Do Some Psychology Researchers Resist Adopting Proposed Reforms to Research Practices? A Description of Researchers' Rationales. *Adv. Methods Pract. Psychol. Sci.* **2018**, *1*, 166–173. [CrossRef]
63. Acevedo, M.M.; Roque, G. Resisting the Deprofessionalization of Instructional Design. In *Optimizing Instructional Design Methods in Higher Education*; IGI Global: Hershey, PA, USA, 2019; pp. 9–26. [CrossRef]
64. Bean, C. *The Accidental Instructional Designer: Learning Design for the Digital Age*; American Society for Training and Development: Alexandria, VA, USA, 2014.
65. North, C.; Shortt, M.; Bowman, M.A.; Akinkuolie, B. How Instructional Design Is Operationalized in Various Industries for job-Seeking Learning Designers: Engaging the Talent Development Capability Model. *TechTrends* **2021**, *65*, 713–730. [CrossRef]

Appendix 2-Article 2: Examining the Characteristics of Practical Knowledge from Four Public Facebook Communities of Practice in Instructional Design and Technology

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RESEARCH ARTICLE

Examining the Characteristics of Practical Knowledge From Four Public Facebook Communities of Practice in Instructional Design and Technology

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ABSTRACT Instructional design and technology (IDT) professionals participate in communities of practice (CoPs) on Facebook to seek pedagogical and educational technology advice for solving instructional design (ID) problems. Much of the IDT literature has focused on formal educational environments and not on nonformal settings outside the classroom and beyond formal education. Further analysis of tacit or practical knowledge exchanged among community members is required to understand the purpose, functions, and organizational knowledge capital in online CoPs. To fill this gap, this study uses natural language processing (NLP) to analyze the practical knowledge of 6,066 anonymized users' posts from four large public IDT CoPs on Facebook from September 2017 to September 2020 after cleaning the dataset. User posts were publicly available and required no password authentication for access, including Instructional Designer (4,717), Designers for Learning (228), Adobe Captivate Users (599), and Articulate Storyline (522). The proposed methodology aims to extract practical knowledge of individual online CoPs in three parts. First, the characteristics of written communication among members are extracted by calculating word and sentence lengths, word frequencies, and contiguous words. Second, the characteristics of members' exchange of practical knowledge are obtained through sentiment identification, entity recognition, and relationships between pedagogical and educational technology entities. Third, the functions of individual online CoPs are developed through topic modeling with latent Dirichlet allocation (LDA) and BERTopic. The findings suggest similarities and differences among IDT CoPs, different resource distribution conventions, and members exchanging pedagogical and educational technology advice. The study highlights the need for pedagogical foundations to support instructional and technical decisions, mechanisms for self-assessment of practical knowledge concerning IDT competencies, community protocols for addressing misconceptions about learning, onboarding materials for new members, and new topic structures to classify practical knowledge. NLP tasks are implemented using Python libraries to support the future development of awareness tools.

INDEX TERMS Data mining, instructional design, online learning, communities of practice, social media.

I. INTRODUCTION

Instructional design and technology (IDT) professionals encounter design problems in most instructional design (ID) projects [1]. Design problems are ill-structured because of various degrees of structuredness, complexity, and domain specificity [2]. Structuredness refers to the multiplicity of design problems that require design judgments, solutions, and evaluation criteria from multiple disciplines. ID projects are complex and possess numerous factors or issues that limit professionals' working memory for finding adequate solutions. Regarding domain specificity, ID projects tend

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to be situated, embedded, and dependent on the nature of the context or domain. In most cases, IDT professionals deal with ambiguous goal specifications and requirements that require the integration of various solutions. These solutions are not always dichotomous but only better or worse. They may require drawing back from past experiences to determine optimal tasks for completing ID projects.

Online communities of practice (CoPs) allow IDT professionals to access tacit or practical knowledge to seek plausible solutions for ill-structured ID projects. IDT professionals can tap into online CoPs' organizational knowledge capital and overcome the limits of bounded rationality through informed exploration of solutions to problems and analogical reasoning [3]. The concept of bounded rationality refers to the limited information, cognitive functions, and amount of time an individual has for decision-making. Analogical reasoning enables better problem representations by generating new solutions from past problems and partitioning problems into meaningful components and tasks that work together. Additionally, online CoPs provide members with professional development (PD) opportunities to enhance their knowledge, skills, and abilities without geographic and temporal constraints [4]. Online CoPs enable IDT professionals to participate flexibly by seeking information or contributing new knowledge while adhering to shared beliefs, identities, and meanings.

Online CoPs on the Facebook platform have played a pivotal role during the COVID-19 pandemic as IDT professionals pivoted from face-to-face to hybrid and emergency remote teaching (ERT) forms of learning. Online learning requires a careful and iterative course design process. In contrast, ERT involves the rapid transition from in-classroom learning experiences to online environments reliably in a short period of time [5], [6], [7]. Abramenka *et al.* [8] investigated how the Instructional Designer Facebook group facilitated peer-to-peer support for IDT professionals during the COVID-19 pandemic. After performing topic modeling on user posts from March 10, 2020, to June 10, 2020, our findings suggested that IDT professionals voiced their expressed needs in five categories, including Educational Technology Advice, Job-Related, Announcement of PD, General Pedagogical Advice, and COVID-Related Pedagogical Advice. Educational technology and job-related user posts were the most solicited categories by IDT professionals during the pandemic. The Instructional Designer Facebook group lacks mechanisms and tools to search the organizational knowledge effectively for solving IDT problems in their organizational settings. Yu [9] also argued that the pandemic accelerated positive interest in online learning. Teachers can provide individualized student-centered instruction and feedback to improve learning outcomes. In addition, learners across different settings reported an increased acceptance of online learning and highlighted network availability issues, online learning outcomes, and student-instructor interactions [10], [11], [12].

The Facebook social media platform has become one of the most palpable online environments for facilitating information sharing, interaction, and collaboration among individuals [13], [14], [15], [16]. Llorens and Capdeferro [16] noted the strengths and issues with Facebook when used as an online collaborative space. The strengths include the simplicity and speed of creating and administering a group, a high degree of connectivity through chat, messaging, tagging, and the platform's extensibility through custom add-on modules. However, shortcomings involve noise elements (e.g., advertising and self-promotion) and the lack of knowledge discovery mechanisms to tag, filter, and organize the constant stream of information. In a similar online CoP called the eLearning Industry, Leung [17] found similar issues related to the lack of mechanisms to reuse practical knowledge in the online news outlet and the lack of alignment of practical knowledge with competencies in IDT established by professional organizations. The American Talent Development (ATD) [18], International Board of Standards for Training, Performance, and Instruction (IBSTPI) [19], Association for Educational Communications and Technology (AECT) [20], and International Society for Technology in Education (ISTE) [21] have developed competencies to encapsulate the professional benchmarks, responsibilities, and capabilities of IDT professionals in different roles (e.g., training manager, evaluator, instructional designer, and instructional technologist).

Studies in the knowledge management literature examine tacit knowledge extraction from explicit forms of knowledge (e.g., online platforms, documents, and e-mail communication) in professional settings through the SECI model, where knowledge is continuously created through socialization, externalization, combination, and internalization [22]. First, tacit knowledge is generated through a socialization process among individuals, and its tacitness is difficult to codify into explicit knowledge. Second, tacit knowledge is externalized in symbolic language for sharing with others. Third, the combination step involves the application and reorganization of explicit knowledge. Fourth, when explicit knowledge is applied, individuals embody the newly acquired knowledge through action and reflection. The present study aims to extract the tacit knowledge from anonymized users' posts that occur at the externalization stage of the SECI model.

The study identified practical knowledge from four public Facebook groups in IDT. Two online CoPs are related to ID, i.e., Instructional Designer and Designers for Education. The other two groups are related to e-learning development, i.e., Adobe Captivate Users and Articulate Storyline. The Instructional Designer Facebook group is the largest public CoP, with approximately 21,700 members [23]. The purpose of this CoP is to share ideas on instructional systems, design, and technology. The Designers for Learning Facebook group is the second-largest public CoP, with approximately 4,400 members [24]. Although the Designers for Learning does not state its purpose, members generally exchange

information on ID practice, mainly in higher education and K-12 settings. The Adobe Captivate Users Facebook group is a public CoP that targets the technical aspects of e-learning development using the Adobe Captivate e-learning authoring tool [25]. This CoP has approximately 2,600 members, but the purpose is not stated. The Articulate Storyline Facebook group targets the technical aspects of e-learning development using the Articulate Storyline e-learning authoring tool. Similar to Adobe Captivate Users, the Articulate Storyline Facebook group does not state its purpose with approximately 5,800 members [26]. As mentioned above, two common characteristics shared among these Facebook groups are the lack of mechanisms to reuse the accumulated organizational knowledge and the misuse of hashtags that contribute little to organizational knowledge management efforts.

This study proposes applying a methodology to extract practical knowledge in individual online CoPs by generating syntactic and semantic features from user posts with natural language processing (NLP). The syntactic aspect refers to the position of words in a sentence without understanding their context. In contrast, the semantic aspect involves extracting the meaning from context words [27]. The syntactic features include generating the average word and sentence lengths, word frequencies, and n-grams. The syntactic features reveal critical characteristics of members' written communication in articulating ID problems and designing solutions. The semantic features include sentiment analysis, named entity recognition (NER) and their relationships, and topic modeling. The semantic features explore the distribution of affective states from user posts, the exchange of pedagogical and educational technology entities, and the latent topic structures that describe the purpose and functions of online CoPs.

The motivations of the study originated from the lack of quantification efforts in identifying the accumulated practical knowledge and types of practical knowledge exchanged in online CoPs. The tremendous amounts of textual data are also increasing daily without real-time mechanisms to automatically categorize practical knowledge and provide users with advanced filtering options to narrow information on social media. The application of topic modeling, mainly latent Dirichlet allocation (LDA), is widely discussed in the literature and allows the categorization of search results and controls for narrowing information based on the users' topic of interest [28], [29], [30]. LDA is an unsupervised, probabilistic, and text clustering algorithm that allows texts to be categorized into topics. The present study opens new opportunities for creating future awareness tools for classifying practical knowledge by implementing topic modeling techniques to uncover emerging topic structures in online CoPs.

The significance of the study explores the accumulated practical knowledge by understanding the purpose, functions, and emerging topic themes from online CoPs. While content analysis is a standard qualitative methodology, the content analysis methodology fails to analyze big data as a whole unit of analysis due to time constraints and increased human error. By performing NLP tasks on individual Facebook groups, the study allows for exploring the formation and exchange of practical knowledge among IDT professionals. This study is a foundational effort for taking an inventory of the accumulated practical knowledge by informing researchers, practitioners, and developers with improved organizational schemes on how to organize and curate practical knowledge as an integral part of community engagement. The following research questions were explored:

RQ1: What are the text characteristics, most frequent words, and word sequences used in online CoPs?

RQ2: What are the characteristics of sentiment, named entities, and relationships among entities in online CoPs?

RQ3: What are the latent topic structures in online CoPs?

Present studies examine the PD needs of IDT professionals in academic and corporate settings. Exploring the sources of practical knowledge is required to understand current organizational knowledge capital and gaps in online CoPs where IDT professionals participate informally. The contributions of this research are as follows:

- Fills a gap in the IDT literature about the characteristics of practical knowledge on social media platforms.
- Identifies how IDT professionals participate in online CoPs.
- Explores integrating practical knowledge into formal IDT education and training as an essential part of problem-solving in ID projects.
- Establishes a foundation for future studies that support the development of intelligence and recommendation systems for skill development and detecting misinformation about learning.

The rest of the article is organized as follows. Section II provides a review of the literature and studies on practical knowledge extraction from online resources. Section III describes the proposed research methodology, including a thorough description of the NLP tasks performed. Section IV contains the results of NLP tasks organized by the research question. Section V discusses the results, recommendations for improving online CoPs, implications for research, practice, and development, and limitations. Section VI concludes the article and provides future directions for this work.

II. LITERATURE REVIEW

The following literature section provides essential concepts that are important to consider for the context of the study. These four concepts relate to how social media supports CoPs, the characteristics and challenges of online CoPs, informal learning, and related studies for extracting practical knowledge using NLP.

A. CoPS AND SOCIAL MEDIA

Lave and Wenger [31] stated that CoPs are characterized by a shared domain of interest, joint community activities, and a shared domain of practice. CoPs act as knowledge stewarding communities where members can organize and manage a body of knowledge from which they draw professional

learning to improve their practice. CoPs also act as a crowdsourcing mechanism where members generate practical knowledge by converting tacit knowledge, or know-how experiences in the field, into explicit forms (e.g., written texts, videos, and graphics).

Online CoPs have become a powerful knowledge-creation mechanism for geographically distributed organizations and individuals [32], [33], [34]. Social media networking sites (e.g., Facebook, Quora, and Twitter) allow members of CoPs to carry out online conversations that serve three educational functions: transactional, transformative, and transcendent [35], [36]. Several studies have investigated the Facebook social media platform as one of the most convenient ways to participate in online CoPs [37], [38], [39], [40], [41], [42]. Ractham and Firpor [43] argued that Facebook is a strong example of the Groundswell phenomenon where individuals use different tools and CoPs to acquire information goods from multiple sources rather than a single entity. This phenomenon also describes online CoPs as delivery mechanisms for information and access points to collective wisdom [44].

B. CHARACTERISTICS AND CHALLENGES IN ONLINE CoPS

A literature review by Abedini *et al.* [45] found that member participation in online CoPs is characterized by professional-centeredness, self-directedness, experience-centeredness, problem-centeredness, and lifelong learning principles. When engaging in online CoPs, members can drive their learning independently and possess an intrinsic motivation to learn relevant skills. Driven by intrinsic motivation, members seek autonomy and self-directness by choosing resources and activities that align with personal and professional agendas. Learning in online CoPs occurs when members reflect upon past experiences and attain new knowledge by reshaping newly encountered information into new solutions. Learning in online CoPs is not fixed to a specific phase of life; it is spread out as members engage and disengage with online CoPs throughout their lifetime. In addition, Abedini *et al.* [45] identified the factors that facilitate and hinder community engagement. The facilitating factors of member engagement include competition to learn new skills, freedom to choose content, an interactive learning environment, engagement in practical and relevant learning experiences, and diverse backgrounds. The hindering factors of community engagement are related to the lack of diverse learning experiences, the steepness of learning new technologies, the directness of learning, the burden of professional workloads, the lack of reflection in learning activities, and the lack of prior experiences to support new learning.

The literature also reports the challenges present in CoPs on Facebook. For example, Mai *et al.* [46] found that online CoPs were mainly text-based environments that led to poor participation and inactive membership. Duncan-Howell [47] found that online CoPs were prone to off-topic conversations, poor navigation, and the personal agendas of self-promoters and influencers. Johnson [48] argued that asynchronous discussions could become inadequate and superficial when they lack coaching and scaffolding. Peeters and Pretorius [49] argued that member participation varies when sharing tacit knowledge in asynchronous environments. Guldberg and Mackness [50] reported that members were overwhelmed with the information presented in online CoPs and suggested developing induction materials and processes to onboard new members. Preece [51] offered usability recommendations to promote collaborative dialogue and participation on social media platforms by improving social interaction, information design, navigation design, and technology access for all community members.

C. INFORMAL LEARNING IN IDT CoPS

Schwier *et al.* [52] argued that IDT CoPs are born of convenience that allows informal engagement to solve specific project challenges or issues. The authors also investigated the features of IDT CoPs in terms of history and culture, mutuality, plurality, and tacit knowledge. They found that shared history and culture are not prominent features. In contrast, passive participation as a spectator was a critical element aligned with practitioners' agendas and community values. In terms of mutuality, community members develop their protocols for contribution and interaction with others. Community participation is based on the plurality of intermediate relationships with other members (i.e., experts in the field) that provide a wide range of considerations and solutions to learning problems.

Online CoPs in IDT are also knowledge repositories where members draw solutions from online resources and conversations without full participation from others. The shared practical or professional knowledge in online CoPs is the product of transforming practical knowledge into explicit knowledge in informal and serendipitous ways. Practical knowledge includes unique or creative solutions to dealing with demanding clients, job aids or templates for applying criteria to projects, and expert advice to solve complex problems.

In addition, online CoPs offer IDT professionals informal learning opportunities to refine their skills over time. Informal learning is unplanned, unstructured, and incidental learning beyond formal settings and is not bound to a specific place or period [8], [53]. Informal learning is influenced by the presence or absence of intentionality and consciousness of learning in self-directed learning and implicit learning or socialization [54]. In self-directed learning, learners attempt activities that are conscious and intentional. In implicit learning, learners are immersed in a context where they are not consciously trying to understand the subject.

Yanchar and Hawkley [55] characterized informal learning resources as practical, purposive, and inescapable as part of ID practice. Informal learning resources were deemed valid because these allowed practitioners to stay current on professional practices by asking peers for feedback and observing other members' work. Informal learning resources were perceived as significant by gradually deepening practitioners'

skills. IDT professionals were also selective in engaging and avoiding informal learning resources based on their time, energy, and perception of the significant opportunity to learn while helping others. The researchers also found two challenges that practitioners encountered in informal learning resources. The first challenge involved the inability to keep up with the stream of constant information. The second challenge was related to the steep learning curve practitioners needed to overcome to meet project demands.

Boling *et al.* [56] and Nelson and Stolterman [57] investigated the tacit beliefs among IDT professionals in 11 design judgments during design activities. The types of design judgment and how these take place during ID activities are summarized below:

1) Framing: Define a space for design activities (e.g., assessing client needs and measuring outcomes).
2) Deliberated off-hand: Recall previous successful judgments that allow for adaptation.
3) Appreciative: Emphasize value on certain design aspects or stages while backgrounding others.
4) Quality: Make decisions about the effectiveness of aesthetic norms and standards of the design.
5) Appearance: Evaluate the quality of the entire design product or experience against heuristics and other successful artifacts or experiences.
6) Connective: Make connections among design objects to create a cohesive artifact or experience.
7) Compositional: Make connections among various design objects central to the artifact or experience.
8) Instrumental: Select a tool or method for the design activity.
9) Navigational: Consider various alternatives to complete a task successfully.
10) Default: Give an automatic response to a triggering circumstance.
11) Core: State or ask the reasoning or meaning behind decisions.

D. RELATED WORK ON PRACTICAL KNOWLEDGE EXTRACTION

Steiger and Steiger [58] argued that tacit knowledge structures represent the implicit mental models of individuals. Mental models are tacit and integrate ideas, practices, assumptions, beliefs, relationships, facts, and misconceptions individuals use to perceive and interact with others [59]. Tacit knowledge has technical and cognitive dimensions containing mental models, values, beliefs, and perceptions. Tacit cognitive knowledge incorporates implicit mental models and perceptions that allow individuals to understand their surroundings and tasks. Tacit technical knowledge is workers' knowledge and abilities to perform functions that are not easily articulated [60]. Viale and Pozzali [61] argued that different forms of tacit knowledge could be acquired and transmitted in the form of competencies, background knowledge, and implicit cognitive rules, as defined below:

- Tacit knowledge as a competence refers to the skills and abilities acquired through apprenticeships and face-to-face interactions.
- Tacit background knowledge includes the regulations, codes of conduct, and acculturation processes to which individuals adhere, based on their context.
- Tacit knowledge acts as a mechanism for creating new knowledge and assessing the accuracy of the information itself.

As a subset of NLP methodologies, topic modeling is used to identify patterns from textual sources to extract hidden themes and insights. In the education domain, Vijayan [62] performed topic modeling with LDA on abstracts and metadata across disciplines from Scopus to generate themes highlighting the challenges, solutions, and inequities in education due to the digital divide during the pandemic. The six themes describe the impact of COVID-19 on higher education, the mental health of health care workers, the teaching and learning experiences during the pandemic, the use of educational technology at higher education institutions, the lessons about treatment strategies, and general reflections on the pandemic. Buenaño-Fernandez *et al.* [63] implemented LDA to investigate a large sample of open-ended teacher feedback from course evaluation surveys to extract strategies (e.g., tutorial and experiential learning) that would lead to student retention in university settings.

In biology and informatics, Gurcan and Cagiltay [64] performed topic modeling on bibliometric data from PubMed, Scopus, and Web of Science to discover the developmental stages in bioinformatics studies from 1970 to 2020. The current direction is toward data analysis tools for statistical estimation and prediction of genomic data, ontology, and protein interactions. In the construction domain, Kim and Chi [65] developed models for retrieving critical information about construction accident cases and classifying the nature of the incidents for safety management. The authors of [65] extracted the semantic similarities in accident reports using a rule-based method and machine learning. With a rule-based approach, information is extracted from an established pattern. In contrast, the machine learning algorithm learns the structure and extracts semantic relationships from the text.

While topic modeling is primarily an unsupervised method for identifying latent topic structures from texts, the generated topic structures can also be used practically to classify future or unseen text sources through awareness tools. These awareness tools take the form of knowledge graphs and content recommendation systems that help with the visualization and summarization of large amounts of text. For instance, Badaway *et al.* [66] leveraged topic modeling to initially assign labels to Wikipedia resources that served as the foundation for implementing interactive knowledge graphs. Knowledge graphs allowed for the visualization of the relationships among resources. Shahbazi and Byun [67] used topic modeling as an exploratory strategy to discover the key characteristics of computer science projects on Twitter that built the foundation for a content recommendation

system. The content recommendation system assisted computer science students with quality control and curation of online resources.

III. PROPOSED METHODOLOGY

This section is organized into three parts. Section A describes user post collection, cleaning procedures, and the environment for NLP tasks. Section B identifies the NLP tasks by the research question, Python libraries, and experimentation details of parameter tuning. Section C provides the evaluation procedures of topic models for obtaining interpretable topics. A summary of the ethical considerations for getting user posts from Facebook groups is discussed in the Appendix.

A. DATA COLLECTION, CLEANING, AND ENVIRONMENT

A total of 7,713 posts from September 2017 to September 2020 were obtained from four Facebook public groups, including Instructional Designer, Designers for Learning, Adobe Captivate Users, and Articulate Storyline. The text sources from each public Facebook group were publicly available and required no password authentication to access users' posts. The mobile version of Facebook (mbasic.facebook.com) showed all the posts available in each group without scrolling through each group's feed for other posts. Once user posts were extracted from individual groups, authorship information and any references to authorship in the posts were deleted to protect users' privacy. The study relied on Jupyter notebooks to fully script NLP tasks in Python 3.7.7, including related libraries described in the Units of Analysis section below. Python was selected over R because of its native integration with application programming interfaces (APIs) and extensibility with web development frameworks.

The number of posts was reduced from 7,713 to 6,066 posts by removing posts that had no context (e.g., "hi," "hi there," "hello all," and "good morning professionals") and checking for any duplicate posts. Additionally, promotional links and multimedia assets that contained no context were removed. Self-promotion can be in the form of advertisements from contractors offering e-learning production services, infographics by e-learning shops (e.g., steps to develop educational animation) and white papers from educational technology vendors as marketing tactics to attract potential clients. Only posts containing evidence of seeking advice or a stance on a given topic were considered in the study. Additionally, emojis in user posts were deleted as part of the data cleaning steps for consistent text analysis across all four online CoPs. Table 1 shows the number of scraped user posts for each Facebook group before and after removing posts with no context and promotional links.

TABLE 1. Number of user posts by Facebook group.

Facebook Group	Number of User Posts (Before Cleaning)	Number of User Posts (After Cleaning)
Instructional Designer	6,000	4,717
Designers for Learning	348	228
Adobe Captivate Users	641	599
Articulate Storyline	724	522
Total	7,713	6,066

B. UNITS OF ANALYSIS

1) TEXT CHARACTERISTICS, WORD FREQUENCIES, AND N-GRAMS

In the first research question, lambda functions were implemented to obtain the average word and sentence lengths of user posts without filtering out stop words to account for all words, including articles, prepositions, pronouns, and conjunctions. The text characteristics of each Facebook group were summarized in the Profile Report package as an exploratory step [68]. Word frequencies were visualized with the WordCloud package to identify prominent words [69]. The n-gram language model in the Natural Language Toolkit (NLTK) library was implemented to create the probabilities of contiguous words in bigrams, trigrams, and 4-grams [70]. The most frequent 4-grams were reported to illustrate word sequences with the highest probabilities. Word frequencies and n-grams required NLP tasks for cleaning, normalizing, and parsing using NLTK by performing lower casing, tokenization, stop words removal, lemmatization, stemming, and tagging parts-of-speech (POS). Although there is no consensus on using a standard stop words dictionary, removing articles, prepositions, pronouns, and conjunctions from textual data is a typical preprocessing step to remove noise or low-level information and reduce training time and dimensionality from uninformative words [71], [72]. This study implemented the stop words English dictionary, Wordnet Lemmatizer, SnowBall Stemmer, and POS tagger libraries in NLTK.

2) SENTIMENT, NAMED ENTITIES, AND ENTITY RELATIONSHIPS

In the second research question, the TextBlob package was implemented for sentiment analysis to identify positive, neutral, and negative attitudes in the posts [73]. User posts were classified as positive (1), neutral (0), and negative (−1). Although the Vader sentiment analyzer is commonly used for social media texts with an informal tone, TextBlob was a better choice for this study because user posts had a professional tone [74], [75]. In addition, the spaCy package was implemented for NER tasks to identify pedagogical and educational technology entities. In NER tasks, spaCy is a rule-based matcher that identifies named entities in texts and classifies entities into standard categories of people, places, organizations, and geographic locations [76]. Once entities were extracted, subject-object relationships emerged as entity pairs to understand how entities were referenced. These entity pairs comprised the source and target entities linked by edge entities that defined relationships among the entities. The most frequent edge entities were reported in the Findings section to explore the exchange of pedagogical and educational technology entities in each online CoP.

3) LATENT TOPIC STRUCTURES WITH LDA AND BERTOPIC

In the third research question, LDA and BERTopic were implemented for unsupervised topic modeling tasks to explore the hidden topic themes in online CoPs. While LDA was the primary topic modeling method for this study, BERTopic was also implemented to explore additional latent topic structures when fitting against a large pretrained sentence transformer model.

In the first topic model, LDA is a generative probabilistic model where text sources are represented by a mixture of hidden topics over the distribution of words [77]. The LDA topic modeling algorithm in the Gensim library generated word representations and probabilities using the bag-of-words (BoW) and Term Frequency-Inverse Document Frequency (TF-IDF) models [78]. In a comparative study of topic modeling algorithms by Albalawi *et al.* [28], LDA is the most popular algorithm that provides useful integrations with NLTK and Gensim Python libraries and allows the development of information retrieval and computational linguistics applications. LDA also provides better accuracy over latent semantic analysis (LSA), nonnegative matrix factorization (NMF), principal component analysis (PCA), and random projection (RP) [28].

Regarding experimentation details, LDA generated two topic models using BoW and TF-IDF. The BoW topic model measured the occurrence of words within the corpus but did not contain information about the order or structure of words. Based on the BoW topic model, the TF-IDF topic model measured the importance of a word based on the occurrences of each word and checked its relevance against the whole corpus. In TF-IDF, a word was considered relevant when it occurred in a few user posts and low if it occurred in many user posts. The topic models mentioned above were created with LDAmulticore to reduce the training time compared to the regular implementation of LDA [78].

LDA required *corpus* and *id2word* parameters. The optional parameters were *chunksize, passes, n_topics,* and densities (*alpha* and *beta*) that needed to be precisely tuned to leverage LDAmulticore. In the *corpus* parameter, the tokenized text source was converted to vectors as a sparse matrix of a number of documents and terms. The *id2word* parameter determined the vocabulary size from the corpus. The *chunksize* and *pass* parameters were set to 100 chunks and 20 passes to determine the number of user posts used in training. The *chunksize* and *pass* parameters were implemented consistently in all Facebook groups. In addition, LDA required a specific parameter for determining the exact number of topics the algorithm needed to achieve distinct and coherent topics. The ideal number of topics (*n_topics*) was performed by running the LDA several times with multiple topic parameters from two (2) to 20 until the elbow method achieved the highest coherence or *C_v* value, as described in Table 2. Finally, the hyperparameters *alpha* for document-topic density and *beta* for word-topic density were set to 'auto,' allowing the LDA algorithm to estimate the document-topic and word-topic densities automatically. The *alpha* hyperparameter controls the mixtures of topics for any given text source. The *beta* hyperparameter controls the distribution of words per topic.

TABLE 2. LDA semantic coherence values and number of topics parameters.

Facebook Group	Semantic Coherence Value	Number of Topics Parameter
Instructional Designer	0.481	5
Designers for Learning	0.376	9
Adobe Captivate Users	0.372	7
Articulate Storyline	0.368	7

In the second topic model, BERTopic is a recent topic modeling technique that leverages Bidirectional Encoder Representations from Transformers (BERT) as a class-based TF-IDF (c-TF-IDF) to calculate words' left and right context and generate interpretable topic representations [79], [80]. In c-TF-IDF, text sources are treated as a single class. Then, the frequency of each word was extracted for each class and divided by the total number of words and posts across all classes. BERTopic supports different pretrained models to understand the context of words based on their surroundings that can be used for supervised and unsupervised NLP tasks [81]. The pretrained sentence transformer model (stsb-bert-large) was implemented to identify semantic textual similarity by reducing dimensionality with the Uniform Manifold Approximation and Projection for Dimension Reduction technique (UMAP) and clustering sentence embeddings with the HDBSCAN algorithm. Although stsb-bert-large was deprecated in early 2022 due to low-quality embeddings, the pretrained model was selected at the time of the analyses in late 2021 because it was optimized for semantic similarity tasks with the ability to map features to a dense vector space.

The experimentation details in BERTopic involved fitting the cleaned user posts as the text sources against the pretrained model in English by automatically generating the number of topics (*nr_topics*) parameter and calculating word probabilities. Although BERTopic can further reduce the generated number of topic parameters with the *reduce_topics* function, the initial experimentation produced a low number of topics with less semantically coherent topic interpretation. Rather than allowing BERTopic to reduce the *nr_topics* parameter automatically, the semantic coherence values were calculated to obtain the highest *C_v* values to determine the appropriate parameter for each Facebook group, as described in Table 3.

C. TOPIC MODELING EVALUATION

Chang *et al.* [82] argued that there is no gold standard for evaluating topic models. The semantic coherence values of the topic models generated with LDA and BERTtopic were examined through quantitative and qualitative approaches. Semantic coherence refers to relevant words with the highest

TABLE 3. BERTopic semantic coherence values and number of topics parameters.

Facebook Group	Semantic Coherence Value	Number of Topics Parameter
Instructional Designer	0.468	5
Designers for Learning	0.503	3
Adobe Captivate Users	0.353	5
Articulate Storyline	0.507	4

probability in a topic that co-occurs within the corpus [83]. In the quantitative approach, the semantic coherence values of topic models were generated by obtaining the highest semantic coherence measures, or C_v values, during parameter tuning. In the qualitative approach, topic interpretation was based on human judgment and subject matter expertise in IDT. Chang *et al.* [82] proposed evaluating topic model outputs using two methods, including topic and word intrusion methods. Regarding topic intrusion, discovered topics were evaluated to determine whether the topic model's decomposition of the text sources agreed with human judgments. In terms of word intrusion, a topic model was examined by observing the words inserted in a topic model that did not provide semantic coherence or coherent meaning. The pyLDAvis package in Gensim [84] and BERTopic visualization functions [85] were used to assist with evaluating LDA and BERTopic topic models, respectively.

In evaluating topic models using LDA, the topic distributions of BoW produced higher topic probabilities than the TF-IDF topic models. The BoW topic models were easier to interpret and provided more nuanced details into IDT. When evaluating topic models using BERTopic, the topic probabilities were nearly similar to those of the BoW topic models. Nevertheless, topic distributions were more general. In Adobe Captivate Users, for example, E-Learning Workflow was the general topic model with BERTopic. In contrast, the BoW topic models contained the specific components of the e-learning development workflow. The generalized nature of topic models in BERTopic was due to the lack of domain-specific knowledge in the pretrained model that was used for fitting the text sources onto the pretrained model. The use of BERTopic also revealed the black box issue where behaviors of the topic modeling algorithm were not observable. Harrison *et al.* [86] reported a similar problem when running topic modeling with the stsb-bert-large pretrained model on team communication transcripts. Unlike BERTopic, the behaviors of LDA can be customized and explained through parameter tuning except for the automatic parameters for *alpha* and *beta* densities. Even though it was impossible to observe the automated nature of calculating *alpha* and *beta* parameters in LDA, a grid search function could have determined the specific density parameters. However, a grid search function may not be feasible to implement as part of awareness tools in a real-world scenario due to its considerable processing time.

IV. FINDINGS

This section is organized into three parts. Section A describes the characteristics of user posts, word frequencies, and word probabilities. Section B identifies user posts' sentiment polarity, entities, and entity relationships. Section C lists the topic structures found in each online CoP using LDA and BERTopic.

A. TEXT CHARACTERISTICS, WORD FREQUENCIES, AND N-GRAMS

1) TEXT CHARACTERISTICS OF USER POSTS

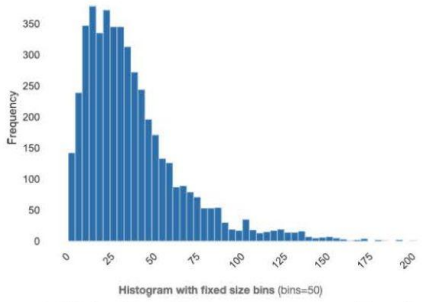
In the Instructional Designer Facebook group, the average word count was 38.75 words, and the average sentence count was 3.14 sentences. The Designers for Learning Facebook group had an average word count of 36.53 words and an average sentence count of 3.20 sentences. In the Adobe Captivate Users Facebook group, the average word count was 44.06 words, and the average sentence count was 3.71 sentences. The Articulate Storyline Facebook group had an average word count of 34.51 words and an average sentence count of 2.63 sentences. The word and sentence length distributions are reported in Fig. 1.

2) WORD FREQUENCIES

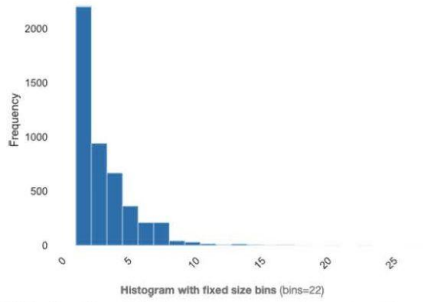
After tokenizing and reducing the vocabulary against the stop words dictionary, the most frequent words emerged as unique tokens or the most representative words of each Facebook group. In the Instructional Designer Facebook group, the most frequent words were *id* (774), *course* (770), and *anyone* (681). In the Designers for Learning, the most frequent words were *learning* (51), *anyone* (42), and *course* (34). In the Adobe Captivate Users Facebook group, the most frequent words were *captivate* (254), *video* (155), and *slide* (153). In the Articulate Storyline Facebook group, the most frequent words were *storyline* (185), *video* (155), and *slide* (127). Fig. 2 contains the word cloud visualizations.

3) N-GRAMS

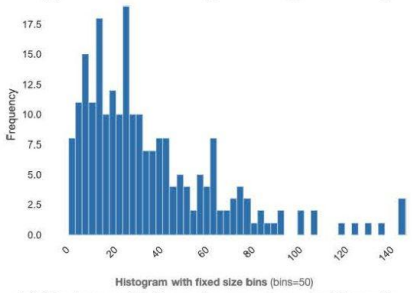
In the Instructional Designer Facebook group, the most frequent 4-grams referenced following specific discussion posts, remote teaching or learning from home, and hashtags (e.g., #elearningtrends). In the Designers for Learning Facebook group, the most frequent 4-grams described engagement strategies in online learning, training facilitation strategies, webinar events, and asking for specific advice related to educational technologies. In the Adobe Captivate Users Facebook group, the most common 4-grams were related to asking for solutions from new users, developing responsive e-learning, asking for examples, and troubleshooting solutions to common problems. The Articulate Storyline Facebook group had the most frequent 4-grams related to sharing video link tutorials and following up on specific posts. Table 4 summarizes each Facebook group's five most frequent 4-grams and frequencies.



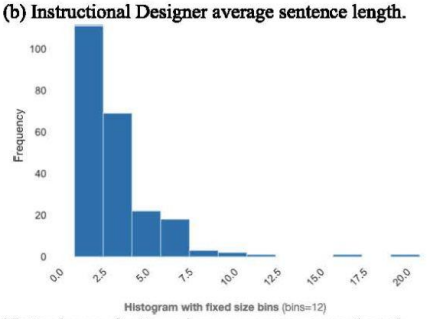
(a) Instructional Designer average word length.



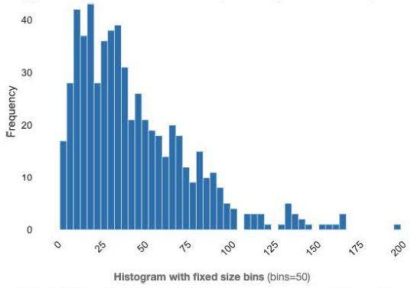
(b) Instructional Designer average sentence length.



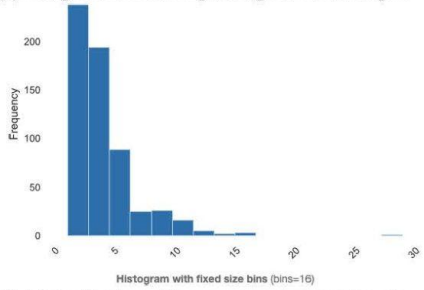
(c) Designers for Learning average word length.



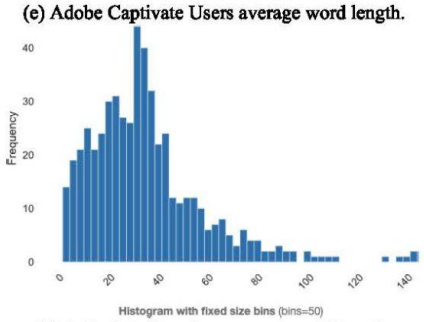
(d) Designers for Learning average sentence length.



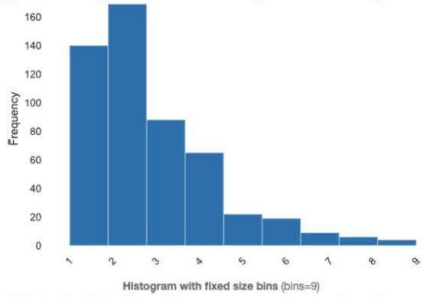
(e) Adobe Captivate Users average word length.



(f) Adobe Captivate Users average sentence length.

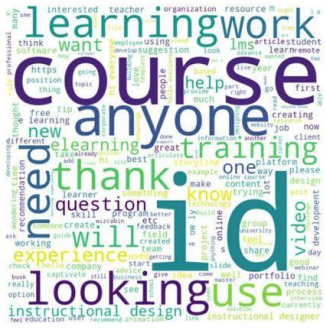


(g) Articulate Storyline average word length.



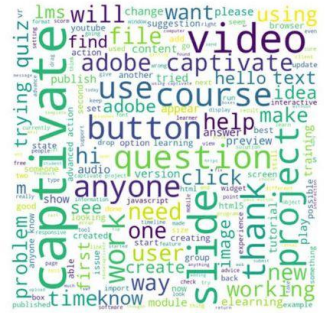
(h) Articulate Storyline average sentence length.

FIGURE 1. Distribution of word and sentence lengths.

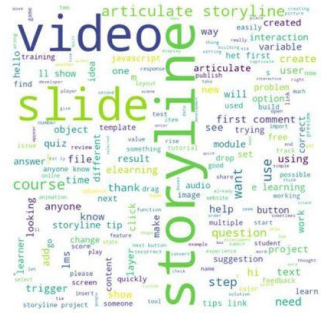


(a) Instructional Designer with 9,411 unique words.

(b) Designers for Learning with 1,768 unique words.



(c) Adobe Captivate Users with 2,717 unique words.



(d) Articulate Storyline 2,110 unique words.

FIGURE 2. Word cloud visualizations.

B. SENTIMENT, NAMED ENTITIES, AND ENTITY RELATIONSHIPS

1) SENTIMENT POLARITY

The Instructional Designer's user posts had a distribution of approximately 70% positive sentiment, 22% neutral sentiment, and 8% negative sentiment. Designers for Learning's user posts showed a distribution of approximately 72% positive sentiment, 22% neutral sentiment, and 6% negative sentiment. Adobe Captivate's user posts had a distribution of approximately 60% positive sentiment, 28% neutral sentiment, and 12% negative sentiment. Articulate Storyline's user posts showed a distribution of approximately 56% positive sentiment, 29% neutral sentiment, and 15% negative sentiment. Table 5 summarizes the sentiment distributions for each Facebook group.

2) RECOGNIZED ENTITIES

The Instructional Designer Facebook group recognized 8,165 entities, including *LMS* (learning management system, 286), *eLearning* (261), *Storyline* (142), *Captivate* (78), *Articulate* (74), and *L&D* (learning and development, 70). Less frequent entities were identified, including *eBook* (56), *SCORM* (40), *ISD* (Instructional Systems Design, 17), *Instructional Design* (4), and *Active Learning* (1).

The Designers for Learning Facebook group had 378 entities recognized. The most frequent entities were *Scratch* (7), *LMS* (5), *OpenLearning* (5), *Designers for Learning* (4), *Articulate Storyline* (3), and *K-12* (3). Less frequent entities were present, including *ADDIE* (1), *UDL* (Universal Design for Learning, 1), *Learning Pyramid* (1), *Cathie Moore* (1), *Stephen Downes* (1), *Jennifer Manddrell* (1), and *Vanessa Alzate* (1). The individuals mentioned earlier were practitioners and researchers noted in the Facebook group.

The Adobe Captivate Users Facebook group had 1,084 entities identified. The most frequent entities were *Captivate* (122), *LMS* (33), *Adobe* (18), *Adobe Captivate* (17), *YouTube* (14), and *SCORM* (11). Less frequent entities were several educational technology tools, including *Camtasia* (3), *Second Life* (2), *Vyond* (2), *SCORMCloud* (1), and *Powtoon* (1).

The Articulate Storyline Facebook group had 954 entities recognized, including *Storyline* (142), *Articulate Storyline* (97), *LMS* (36), *Articulate* (16), *eLearning* (12), and *SCORM* (12). Less frequent entities were related to the integration of e-learning courses with LMS platforms and other tools, including *Articulate Rise* (5), *Lectora* (3),

TABLE 4. Most frequent 4-grams and frequencies.

Facebook Group	4-Gram	Frequency
Instructional Designer	(*u, learningpark, learn, right*)	9
	(*learningpark, learn, right, way*)	9
	(*follow, u, learningpark, learn*)	9
	(*learningfromhome, onlineteaching, onlineeducation, teachersofinstagram*)	7
	(*learningeveryday, lifelonglearning, keeplearning, neverstoplearning*)	7
Designers for Learning	(*learning, designer, showcasing, best*)	4
	(*facilitate, engaging, online, course*)	4
	(*online, course, hope, see*)	4
	(*best, use, social, learning*)	4
	(*might, relevant, anyone, looking*)	4
Adobe Captivate Users	(*hi, im, new, group*)	3
	(*im, using, drag, drop*)	2
	(*one, whole, quiz, project*)	2
	(*adobe, captivate, 2019, update*)	2
	(*responsive, mode, csv, format*)	2
Articulate Storyline	(*storyline, tip, link, het*)	20
	(*ill, show, step, step*)	20
	(*tip, link, het, first*)	20
	(*link, het, first, comment*)	20
	(*see, video, first, comment*)	20

TABLE 5. Sentiment distribution of user posts.

Facebook Group	Positive	Neutral	Negative	Total
Instructional Designer	3,298	1,011	408	4,717
Designers for Learning	163	52	13	228
Adobe Captivate Users	358	165	76	599
Articulate Storyline	294	149	79	522

SharePoint (3), and *Canvas* (1). Fig. 3 shows the distributions of the most frequent entities.

3) ENTITY RELATIONSHIPS

After performing entity recognition in each group, prominent relationships between entities emerged when community members used specific words. In the Instructional Designer Facebook group, 1,908 entity relationships were identified. Community members used words (e.g., *thanks, thank, want*) to exchange suggestions and solicit help related to e-learning development (e.g., storyboarding, development hourly cost), ID graduate programs, online workshops, PD, and job opportunities.

In the Designers for Learning Facebook group, 173 entity relationships were identified. Community members used words (e.g., *thanks, want, see*) to share online workshops and resources to support teaching practices. Additionally, the entity relationships suggested that members use the group to seek feedback from others (e.g., a member's custom e-learning course, online ID portfolio) and advice for selecting educational technology tools (e.g., Scratch for game development).

In the Adobe Captivate Users Facebook group, 342 entity relationships were identified. Community members used words (e.g., *thanks, thank, help*) to seek technical solutions to e-learning development using Adobe Captivate. Community members in this group were particularly interested in asking questions about media production, 360 immersive videos, e-learning interactions (e.g., drop-down menus, image sliders, quiz items), accessible e-learning, and operating system specifications for the authoring tool.

In the Articulate Storyline Facebook group, 286 entity relationships were identified. Community members used words (e.g., *thanks, thank, link*) to share instructional video tutorials and exchange tips on using Articulate Storyline. These tips and tricks involved video and quiz triggers using JavaScript and variables in the standalone version of the tool and integration with the web-based e-learning authoring tool (i.e., Articulate Rise). Table 6 summarizes each Facebook group's ten most frequent entity relationships and frequencies.

C. LATENT TOPIC STRUCTURES WITH LDA AND BERTOPIC

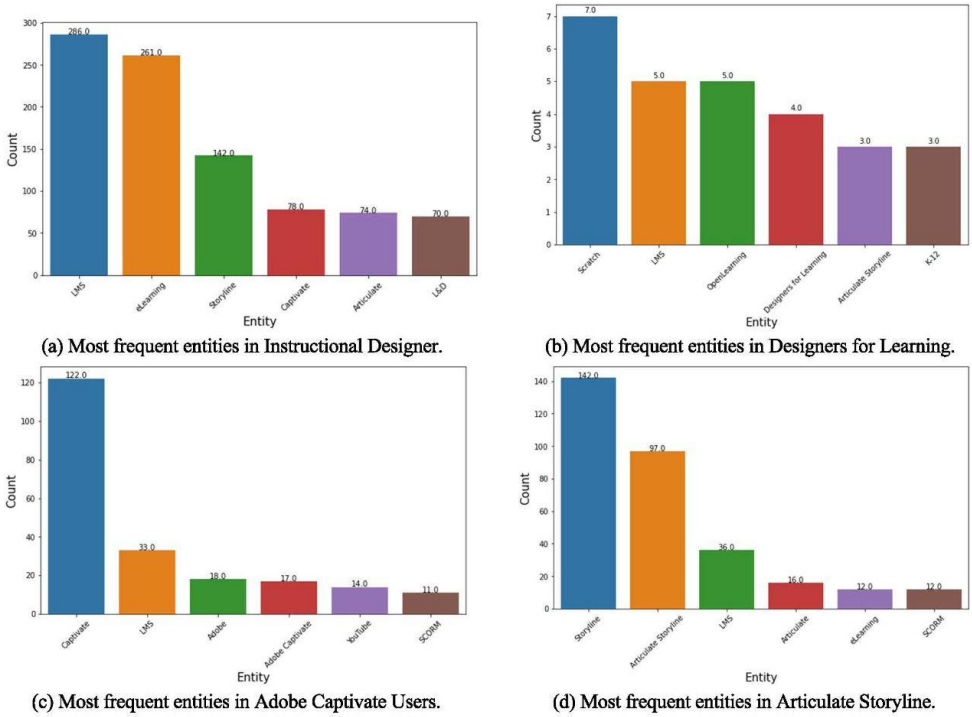
The BoW topic models had better topic interpretation based on subject matter interpretation and higher probabilities of topic distributions than TF-IDF topic models. BoW topic models generated the majority of the topics with a higher degree of specificity in IDT. Nevertheless, the topic models using BERTopic developed fewer topics that were more general, with little detail in pedagogy and educational technology. The topic models generated by BERTopic are a great example of how domain-specific models are needed to create better topic representations. Table 7 summarizes the emerging topic patterns for each Facebook group using the BoW and sentence transformer topic models.

V. DISCUSSION

This study examined 6,066 user posts from four CoPs in IDT on the Facebook social media platform from September 2017 to September 2020 to better understand the characteristics and emerging topic themes in practical knowledge. This study offers several findings that provide valuable information for researchers and practitioners in the IDT field. The study also suggests development considerations for machine learning operations (MLOps) that allow for the future development of complex, scalable, and robust NLP tools to enhance community members' ability to browse and filter practical knowledge in asynchronous online environments. A discussion of the findings, implications, and limitations are summarized below.

A. GENERAL, UNIQUE, AND SHARED CHARACTERISTICS AMONG IDT CoPS

As a social media platform, Facebook groups facilitated the exchange of practical knowledge among IDT professionals through opportunities for informal PD and just-in-time



(a) Most frequent entities in Instructional Designer.

(b) Most frequent entities in Designers for Learning.

(c) Most frequent entities in Adobe Captivate Users.

(d) Most frequent entities in Articulate Storyline.

FIGURE 3. Most frequent entities.

interventions. The findings showed general characteristics regarding members' written communication and sentiment. As a general characteristic, community members in the four Facebook groups used four sentences or less and 45 words or less to seek pedagogical and technical advice. In the Instructional Designer and Designers for Learning Facebook groups, these online CoPs had almost similar sentiment distributions from 70%–72% for positive sentiment, 22% for neutral sentiment, and 6%–8% for negative sentiment. In the Adobe Captivate Users and Articulate Storyline Facebook groups, these online CoPs also had almost similar sentiment distributions from 56%–60% for positive sentiment, 28%–29% for neutral sentiment, and 12%–15% for negative sentiment.

The findings suggested unique and shared characteristics that revealed the purpose behind online CoPs in IDT. Based on the topic structures, the unique features of the Instructional Designer Facebook group were related to asking peers to review ID portfolios and soliciting resources for educational animation development. The unique characteristics of the Designers for Learning Facebook group were associated with the development of serious games for learning, online game development, and educational technology tools. The shared characteristics of the Instructional Designer and Designers for Learning Facebook groups were in the areas of ID graduate programs, job postings, event announcements, and general resources for online course development and online training in higher education and private settings, respectively.

When comparing the topic models, the Adobe Captivate Users Facebook group's unique characteristics were mobile development, e-learning course integration in LMS platforms, and e-learning development workflow. In contrast, the unique characteristics of the Articulate Storyline Facebook group pertained to the integration of JavaScript with Articulate Storyline outputs. Because of the similar purpose behind the e-learning authoring tools, it was not surprising to observe shared characteristics in the technical aspects of the software related to manipulating slide properties, quizzes, virtual reality, and multimedia components.

B. INTENTIONALITY BEHIND COMMUNITY MEMBERS' POSTS

The findings suggested an active exchange among community members in all Facebook groups by stating appreciation when members received answers from others. The results

TABLE 6. Most frequent entity relationships and frequencies.

Facebook Group	Recognized Entity	Frequency
Instructional Designer	thanks	263
	thank	153
	want	56
	use	54
	advance	50
	known	48
	appreciated	46
	think	43
	help	41
	tia	40
Designers for Learning	thanks	105
	want	5
	see	4
	make	4
	appreciated	3
	thank	3
	wanted	3
	know	3
	help	3
	learn	3
Adobe Captivate Users	thanks	37
	thank	19
	help	17
	ideas	11
	suggestion	10
	need	10
	captivate	10
	know	9
	get	9
	want	8
Articulate Storyline	thanks	26
	see	23
	link	20
	help	13
	thank	12
	want	12
	thx	11
	use	10
	add	8
	create	8

align with Evans *et al.*'s intentionality and consciousness of self-directed learning, where community members sought solutions independently [54]. The findings also showed the cognitive dimension of CoPs' organizational knowledge capital as members pursued collective goals with established norms and behaviors [60]. In the Instructional Designer and Designers for Learning Facebook groups, the intentionality and consciousness of self-redirected learning occurred when members requested advice about e-learning development processes, learner engagement strategies, multimedia development, ID graduate programs, and ID jobs. In the Adobe Captivate and Articulate Storyline Facebook groups, members had conscious efforts in seeking help with the technical aspects of e-learning authoring tools.

Furthermore, each online CoP had different conventions for distributing informal learning resources. The Instructional Designer Facebook group relied heavily on hashtags to allocate resources for e-learning development and courseware integration with LMS platforms. Additionally, the Instructional Designer Facebook group members followed specific user posts deemed valuable. Based on the entities extracted, this online CoP attracted IDT professionals from a wide array of work settings, mainly in L&D settings in the private sector. In the Designers for Learning Facebook group, members discussed learner engagement strategies, gamified learning, and free PD opportunities. Although the distribution of resources was not present in the Adobe Captivate Facebook group, members relied heavily on others to solve technical questions related to the Adobe Captivate software. Additionally, new members in the Adobe Captivate Facebook group tended to introduce themselves to the group before requesting advice. In the last Facebook group, members of the Articulate Storyline relied on videos that community administrators shared, and members asked questions about the location of the resources in the online CoP. Community administrators also tended to misspell definite articles (i.e., *het* instead of *the*), as seen in Table 4.

C. TYPES OF PRACTICAL KNOWLEDGE

The exchange of practical knowledge was observed as members offered solutions to others through design judgments. In the Instructional Designer and Designers for Learning Facebook groups, members framed and deliberated off-hand design judgments as they inquired about converting face-to-face training to an online format while keeping learners engaged. Additionally, members exhibited appearance, compositional, connective, and quality design judgments when reviewing ID portfolios and sample e-learning courses requested by other members. In the Adobe Captivate Users and Articulate Storyline Facebook groups, members showed default design judgments as they solved technical issues about manipulating various properties for quizzes, slides, and multimedia.

Seeking advice related to educational technology was prevalent in online CoPs. In examining the frequencies of all extracted entities, however, pedagogical entities were less frequent than educational technology entities. For instance, the less frequent pedagogical entities in the Instructional Designer Facebook group were ISD, learning styles, and e-learning design. The less frequent pedagogical entities in the Designers for Learning Facebook group were UDL, ADDIE, and Learning Pyramid. The learning styles myth suggests that learning can be acquired in distinctive ways through visual, auditory, and kinesthetic channels. The learning pyramid myth indicates that different learning activities are associated with memory retention rates. The learning pyramid is the product of misusing Dale's research on continuity of learning through experience, where learning occurs on a concrete to abstract continuum using audiovisual media options [87].

Although pedagogical entities related to learning styles and learning pyramid were present to a lesser degree in the Instructional Designer Facebook group, members either debunked or spread these learning myths. Spreading these learning myths showed the lack of community protocols to provide corrective actions or clarifications. In the Adobe

TABLE 7. Emerging topic patterns.

Facebook Group	Topic	Bag-of-Words Topic Model	Sentence Transformers Topic Model
Instructional Designer	Topic 1	ID Programs	Educational Animation
	Topic 2	E-Learning Development	E-Learning Training Resources
	Topic 3	E-Learning Engagement Practices	ID Jobs
	Topic 4	E-Learning Software	ID Experience
	Topic 5	Simulation Development	ID Portfolio Development
Designers for Learning	Topic 1	Video Development	Free Resources and Events
	Topic 2	Online Course Development	Online Game Development
	Topic 3	Online Training Development	ID Jobs
	Topic 4	Video Development	
	Topic 5	Research EdTech Tools	
	Topic 6	Coding and Game Design	
	Topic 7	ID Profession	
	Topic 8	Serious Games	
	Topic 9	ID Programs	
Adobe Captivate Users	Topic 1	E-Learning Output	E-Learning Workflow
	Topic 2	Quiz Tracking	Adobe Captivate for New Users
	Topic 3	Video Development	Virtual Reality
	Topic 4	Slide Questions	Version Questions
	Topic 5	Mobile Development	Integration with CMS/LMS
	Topic 6	Slide Questions	
Articulate Storyline	Topic 1	Object Triggers	Slide Questions
	Topic 2	Slide Questions	Integration with JavaScript
	Topic 3	Layer Troubleshooting	Virtual Reality
	Topic 4	Quiz Tracking	Quiz Tracking
	Topic 5	Slide Questions	
	Topic 6	E-Learning Development	
	Topic 7	Video Development	

Captivate Users and Articulate Storyline Facebook groups, pedagogical entities were absent because these online CoPs were used for troubleshooting software issues. However, cognitive load theory, cognitive theory of multimedia learning, and Section 508 for accessibility are critical pedagogical concepts and frameworks for e-learning development.

D. THE NEED FOR PEDAGOGICAL FOUNDATIONS

Even though pedagogical entities were less frequent in the Instructional Designer and Designers for Learning groups and nonexistent in the e-learning development software Facebook groups, the real-world applications of pedagogical concepts are critical to the IDT profession. Without pedagogical foundations, IDT professionals risk designing online learning experiences with a heavy emphasis on technology delivery mechanisms without proper technology integration considerations and perpetuating the misconceptions of the IDT role, primarily for e-learning materials development and technology support. The focus on e-learning materials production has also been reported in Leung [17], where a large online CoP in IDT, called the eLearning Industry, prioritized e-learning development over pedagogical concepts in online articles written by IDT professionals. Recent research has also highlighted the need for information hubs to ensure continuity of learning during times of crisis [88], [89], [90]. Information hubs, or COVID-19 response online resources, do not currently exist in these online CoPs. Pedagogical resources should be integrated into online CoPs to support IDT professionals' abilities to design online and hybrid learning experiences and properly incorporate educational technology.

The real-world applications of pedagogical concepts have implications when designing compelling online and blended learning experiences in various settings. Although this study highlights the need for pedagogical foundations in online CoPs, it does not intend to list all frameworks, concepts, and theories to guide the design of online and blended learning that lead to positive outcomes for learners and instructors. An example of applying pedagogical concepts to ID projects is explained in a book chapter on Managing ID Projects in Higher Education [91]. IDT professionals in higher education perform five types of ID projects that involve pedagogical concepts to guide decision-making as follows:

1) Course Development: Collaborating with faculty and staff to develop new courses, redesign existing courses, and enrich in-person courses with educational technology with quality assurance (e.g., UDL, Bloom's Taxonomy, Community of Inquiry, Backward Design).
2) Institutional Learning Initiatives: Leading or supporting pedagogical approaches (e.g., microlearning, service learning, gamed-based learning) and technology initiatives (e.g., proctoring platforms, content curation, video conferencing).
3) Workshops: Aligning and evaluating the impact of educational technology through technology integration frameworks (e.g., Technology Acceptance Model

(TAM); Replacement, Amplification, and Transformation (RAT); Substitution, Augmentation, Modification, and Redefinition (SAMR); Technology Integration Matrix (TIM)).

4) Quality Assurance: Implementation of course development and quality assurance procedures (e.g., Quality Matters Higher Education rubric).
5) Support: Supporting stakeholders regarding educational technology, pedagogy, and accessibility.

Additionally, project management is critical for handling ID projects by leveraging interpersonal, technical, and administrative skills. Even though pedagogical concepts are essential in higher education, these concepts are still applicable in different professional settings. Several IDT Open Educational Resources (OERs) can be found on OER Commons [92]. IDT CoPs may choose to curate resources that build the necessary pedagogical foundations, especially for newly minted IDT professionals.

E. IMPLICATIONS

The findings of the study have several implications for research, practice, and MLOps.

1) IMPLICATIONS FOR RESEARCH

Erden *et al.* [93] argued that research on the collective quality of practical knowledge is required to understand organizations' knowledge creation capabilities. The authors also suggested that the collective quality of practical knowledge can be examined on four levels: Group as Assemblages, Collective Action, Phronesis, and Collective Improvisation. Online CoPs are newly formed in the first level, where members share no collective history or understanding. In the second level, collective action is defined by shared memory and knowledge for solving problems and adopting group-based routines as an integral part of the community culture. In the third level, phronesis refers to the collective actions that online CoPs take to advance goals guided by shared culture and values. Additionally, the collective quality of practical knowledge emerges in the third level, where members articulate solutions to familiar problems. In level four, collective improvisation is the highest level of practical knowledge, where online CoPs respond quickly to unpredictable situations.

Based on the observed entity relationships, 4-grams, and topic models, the collective quality of practical knowledge in the online CoPs of interest operated at the second level, where community members actively exchanged pedagogical and educational technology advice as part of the cultural routine. Although topic models can be used to assert the overall quality of practical knowledge in online CoPs, it is crucial to understand that online CoPs can operate at the third level of phronesis or the fourth level of collective improvisation, where members can improvise solutions to unfamiliar challenges. As part of the Instructional Designer Facebook group's culture, for example, the ID Portfolio Development topic model involves providing feedback on portfolios that are inherently diverse in creativity based on professional backgrounds and goals for applying to specific jobs. In another instance, the Designers for Learning Facebook group may also operate at the fourth level of collective improvisation when encountering unfamiliar topics regarding new research on educational technology and game design tools. Last, the Adobe Captivate Users and Articulate Storyline Facebook groups operated at the second level of collective action when solving common technical issues of the e-learning software. In addition, e-learning development software CoPs can perform at higher levels when encountering new challenges and opportunities in updated software versions.

Further research is required to understand how members of online CoPs engage at level three of phronesis and level four of collective improvisation through discourse analysis, sequential pattern analysis, or process mining. Research on how topic models evolve can also demonstrate how community priorities and goals shift. The evolution of topic models can provide insights into online CoPs' abilities to respond to unpredictable circumstances.

2) IMPLICATIONS FOR PRACTICE

Professional organizations, IDT education and training providers, leaders of online CoPs, and e-learning development software companies can be informed through the study about how community members participate when seeking pedagogical and educational technology solutions.

Professional organizations can identify topic patterns in practical knowledge online CoPs when IDT professionals exchange pedagogical and educational technology advice. Professional organizations can also benefit from the findings by examining their frameworks against the discovered entities and topic models. The results of the study highlight the need to research the extent to which competencies and standards in IDT align with practical knowledge present in online CoPs. Thus, further investigating the alignment between online CoPs' practical knowledge and competencies identifies the gaps and opportunities for targeted PD opportunities. A further investigation is needed to understand how IDT professionals apply newly acquired practical knowledge in different settings (e.g., K-12, higher education, and private settings) and how it is internalized into their professional practice.

IDT education and training providers can identify formal and informal learning opportunities that enhance the pedagogical foundations of IDT students and professionals. IDT faculty are informed of types and topic patterns in practical knowledge that can be incorporated into IDT programs and internships. IDT students can leverage the accumulated practical knowledge in online CoPs to seek solutions to academic coursework and receive informal student portfolio reviews. Although the extracted educational technology entities were more prevalent than pedagogical concepts, informal learning opportunities can enhance the pedagogical foundations of IDT professionals by exploring research and implementation trends in

higher education, K-12, and private settings. In higher education, the 2022 Educause Horizon Report describes redefining instructional modalities that affect how institutions develop new courses two years after the COVID-19 pandemic [94]. IDT professionals in K-12 settings can learn about the trends in the USA through the Condition of Education 2022 report by the National Center for Education Statistics [95]. IDT professionals in private settings can benefit from exploring workplace reports by the ATD [96].

Community leaders of Instructional Designers and Designers for Learning Facebook groups can better understand the emerging topic structures in online CoPs by devising mechanisms for better knowledge sharing and discoverability within the technological limits of the Facebook platform. While Facebook groups facilitate the exchange of practical knowledge in an asynchronous environment, three recommendations are necessary to sustain online CoPs by creating mechanisms for reusing knowledge, onboarding new members, and adopting a culture of accountability through professional competencies. The first recommendation is to develop better mechanisms for reusing existing knowledge to make knowledge more discoverable by members. Rather than using hashtags to distribute content, the topic structures found in this study can be used to design content structures that classify cognitive and technical practical knowledge. By developing a new set of hashtags that organizes practical knowledge, such hashtags can be used to filter specific functions of the online CoP and types of practical knowledge as follows:

1) Instructional strategies and theories.
2) E-learning workflows for face-to-face to online and blended formats.
3) Educational technology tips.
4) ID jobs and career advice.
5) Feedback on online and blended learning experiences and portfolios.
6) PD resources and events.

The second recommendation is to create specific onboarding for new members by stating the online CoP's purpose, protocols for sharing knowledge, and the types of practical knowledge available. The third recommendation is to adopt a culture of accountability in which leaders and members of online CoPs fact-check information and discourage misinformation by adopting professional competencies that allow IDT professionals to self-assess their practice.

Software companies can design better support mechanisms that address users' most challenging technical aspects of e-learning development in their respective CoPs on Facebook and support websites. The Adobe Captivate support website currently organizes troubleshooting discussions in 15 categories with general and in-depth aspects of the software. Nevertheless, the support website lacks additional in-depth topic categories and issues (e.g., slide manipulation and response templates for mobile) that users encounter on the Facebook group [97]. The Articulate Storyline support website does not provide users with topic categories to organize software-related issues. Instead, users rely on threaded discussions to find solutions on the Articulate Storyline support website [98]. Although it is unknown whether the e-learning development software companies endorse their respective Facebook groups, online CoPs and support websites lack search mechanisms for allowing members to seek technical solutions independently. Moreover, these companies benefit from the findings by integrating the topic categories with consistent hashtags in both online CoPs and support websites.

3) IMPLICATIONS FOR MLOPS

The study implemented NLP tasks in an unsupervised manner to discover the patterns in practical knowledge in online CoPs. The study established a critical foundation for understanding member interactions and exchanging practical knowledge. The study also provided lessons for MLOps about producing machine learning (ML) models as awareness tools to provide insights into the patterns of the accumulated practical knowledge. MLOps are a set of practices where ML models are brought into production to increase quality, management, monitoring, and automation in large-scale production environments. Furthermore, developing awareness tools can be guided by understanding the factors that impact positive outcomes in online learning. In a meta-analysis of online learning studies from 1998 to 2021, Yu [99] found that behavioral intention, instruction, engagement, interaction, motivation, self-efficacy, performance, satisfaction, and self-regulation were critical factors in online learning. Shaik *et al.* [100] argued that implementing NLP has implications for improving learning processes in online environments in five categories: understanding the end user without human intervention, adapting learning environments, automating repetitive tasks, personalized guidance and motivation, and monitoring learner progress.

The Python code used in the NLP tasks supports the development of ML models as dashboard components that can help online CoPs in engagement, satisfaction, and self-regulation. ML models can assist members and leaders in overcoming the issue of knowledge discoverability at the member and leadership levels. For example, a member dashboard can contain four components and their respective Python libraries to visualize word frequencies with WordCloud, classify user posts by topic categories with LDA, organize pedagogical and educational technology entities with spaCy, and classify entities by topic categories with spaCy and LDA. At the leadership level, an administrative dashboard provides a high-level view of the online CoP by integrating five components to identify topic patterns in user posts, summarize word frequencies, identify sentiment and assign topic categories with TextBlob and LDA, count pedagogical and educational technology entities in topic categories, and count user posts in the form of word frequencies with lambda functions.

In higher education, the Python code also supports the future development of awareness tools in LMS platforms for IDT education. The accumulated practical knowledge from online CoPs and past online IDT courses assists

students in seeking potential solutions to ID problems. Recent research on ML models in LMS platforms has focused on predictive tasks with continuous or numerical features, such as predicting student performance, providing resource recommendations, developing learner profiles, and automating feedback based on student performance [101], [102], [103], [104], [105], [106], [107], [108]. However, the integration of accumulated practical knowledge from formal and informal sources using NLP attributes has not been developed in LMS platforms. Integrating practical knowledge sources in LMS platforms can provide IDT students with real-world solutions and prevent them from accessing multiple information sources to solve ID projects during coursework.

Huyen [109] argued that ML models must align with the objectives that ultimately lead to positive outcomes. Additionally, ML models must be reliable, scalable, maintainable, and adaptable to operate efficiently at scale. Integrating ML models on social media platforms can positively impact the discoverability of practical knowledge while promoting engagement, satisfaction, and self-regulation. In higher education, integrating ML models in LMS platforms can provide IDT students with the ability to solve ID projects by accessing the accumulated practical knowledge in online CoPs and discussion boards from past online IDT courses while promoting self-directed learning. In the proposed methodology, the NLP tasks provided reliable word frequencies, entities, sentiment analysis, and topic structures by implementing the respective stop words dictionary, lists of features for identifying entities and sentiment, and appropriate semantic coherence scores for topic modeling. Although the NLP tasks were performed locally, the NLP tasks may present scalability issues in a real-world context when processing a large corpus from social media sources. For example, the text processing of the large corpus in the Instructional Designer Facebook group was the most time-consuming aspect because of the rule-based nature of word frequencies and entity matching against a dictionary of words during the POS tagging process and the list of entity categories for classifying entities, respectively. Even though the topic modeling component was an easy task, parameter tuning for obtaining semantically coherent topics required a significant processing time. Concerning maintainability, the Python code used in NLP tasks is reproducible in testing and production environments. Nevertheless, optimization techniques are needed to reduce errors and latency between the hosting server of the ML models and users' dashboards.

While the proposed approach used three years of public data for training purposes, future experimentation and testing are required to examine the quality of produced topic models on new text sources, types of processing (i.e., batch or on-demand processing), data cleaning of self-promotion and spam, and storing analytical insights in cloud services. As ML models degrade due to the growth of practical knowledge, updating entity dictionaries is necessary for tracking the performance of ML models when new entities are created. Monitoring the semantic coherence scores in ML models is another critical task when semantic scores fall below a given threshold, which leads to low-quality interpretable topic structures. Regarding the types of processing, batch and on-demand processing are two options available for processing text sources. On-demand processing via cloud services is the ideal solution, but further analyses of cost and usability requirements are needed to determine the best processing choice. Although the study relied on the manual identification of posts related to self-promotion and advertisements, the NLP tasks need to implement additional code to correct grammatical mistakes and delete irrelevant user posts to ensure the reliable generation of topic structures. The last indispensable features are scaling text processing capabilities and adjusting the cloud's storage capacities of analytical insights.

Before ML models are deployed in cloud services, the NLP tasks implemented in the study require further optimization techniques to increase robustness. Omar *et al.* [110] argued that NLP is susceptible to adversarial attacks that lead to corrupted predictions. In their literature review of the robustness of NLP, the authors stated that robustness analysis tools, robustness metrics, and defense mechanisms are required for creating robust NLP pipelines after deployment in the real world. Concerning robustness analysis tools, NLP tasks require further robustness analyses to mitigate adversarial attacks that may occur during deployment, including the CheckList by Ribeiro *et al.* [111], Robustness Gym by Goel *et al.* [112], and WildNLP by Rychalska *et al.* [113]. Robustness metrics are also necessary to measure the robustness of the proposed method by obtaining three metrics, including attack success rate, error rate, and interval bound propagation (IBP) bound tightness, to understand the level of normal accuracy and training accuracy during word substitution attacks. Finally, the NLP tasks require a defense mechanism through data augmentation when processing input text sources in a real-world scenario. In data augmentation, input words are masked to defend against word substitution and character-level attacks.

F. LIMITATIONS

The present study was not without limitations. Community members posted links to resource documents, blogs, video tutorials, and research papers that were not analyzed because the textual data were outside the Facebook platform. A significant amount of practical knowledge was contained in these external resources. Nevertheless, external resources were not analyzed due to additional data cleaning mechanisms required to extract text from documents and obtain video transcriptions.

VI. CONCLUSION AND FUTURE WORK

The study provided a systematic approach to examining tacit or practical knowledge from four CoPs when IDT professionals attempted to solve design problems asynchronously on the Facebook social media platform. By examining the written communication in each online CoP, the study

quantified the organizational knowledge capital, types of practical knowledge, and hidden topic patterns. The study documented the frequency and exchange of pedagogical and educational technology entities. This study also uncovered an active exchange of cognitive and technical dimensions of tacit knowledge. Tacit cognitive knowledge was present in the Instructional Designer and Designers for Learning Facebook groups about implementing instructional and assessment strategies, making career suggestions, presenting effective e-learning production workflows, and evaluating ID portfolios. Tacit technical knowledge was observed in the Adobe Captivate Users and Articulate Storyline Facebook groups regarding manipulating e-learning development software and integrating online courseware in LMS platforms. The findings provided recommendations for organizing the accumulated practical knowledge that allows community members to seek design solutions independently. Though active member participation occurs in online CoPs, community leaders must devise protocols for correcting misconceptions about learning and aligning their current organizational practical knowledge to professional benchmarks to enable self-evaluation of members' tacit cognitive knowledge. The findings provide opportunities for targeted PD in the learning sciences to enhance the pedagogical foundations of IDT professionals. Community leaders should include pedagogical resources to support IDT professionals' PD needs and decision-making of educational technology tools. It is also imperative for online CoPs to become information hubs to support instructional decisions during unprecedented circumstances that require a rapid shift from in-person learning to online, blended, and hybrid-flex forms of learning. The study established a foundational step for the future development of awareness tools to facilitate community members' exchange of design solutions for ID projects.

The future directions of the study involve the following:

- Investigating user posts by sentiment to discover the challenging aspects of ID projects from the practitioner's perspective.
- Examining practical knowledge to understand the collective quality of practical knowledge and evolution of topic models in online CoPs.
- Creating a comprehensive entity dictionary from online CoPs to investigate practical knowledge in IDT CoPs on different platforms.
- Testing the development of APIs to support native and third-party integration of awareness tools to assist online CoP leaders and members with knowledge discoverability of practical knowledge.

APPENDIX

Even though web scraping is still a relatively new and emerging practice, Krotow and Silva [114] argued that ethical issues are associated with the automatic extraction of information. According to the authors [114], web scraping entails five ethical considerations: individual privacy and rights of research participants, discrimination and bias, organization privacy, diminishing organizational value, and impact on decision-making. Even though web scraping involves ethical hurdles to academic researchers and Terms of Service (TOS) explicitly prohibits web scraping and crawling of their platforms, Mancosu and Vegetti [115] noted that scraping public information from online platforms may be safe for researchers because research on social media serves the public interest. Additionally, Catanese *et al.* [116] argued that TOS is designed to perverse the status quo by enforcing behavioral and technical limitations to web scraping.

Technology plays a critical role in sustaining knowledge creation and sharing. Nevertheless, it can result in negative consequences when comparing online CoPs because of the lack of anonymity and privacy that lead to unintended identification of users when searching for authorship of posts on Facebook. For this reason, any identifiable information (i.e., links to public posts and authorship) was deleted to ensure the anonymity and privacy of users. Text sources are not publicly available to prevent plagiarism and protect online CoPs' organizational knowledge [117].

REFERENCES

[1] J. Stefaniak, J. Baaki, and L. Stapleton, "An exploration of conjecture strategies used by instructional design students to support design decision-making," *Educ. Technol. Res. Develop.*, vol. 70, pp. 1–29, Feb. 2022.
[2] D. H. Jonassen, "Toward a design theory of problem solving," *Educ. Technol. Res. Develop.*, vol. 48, no. 4, pp. 63–85, 2000, doi: 10.1007/BF02300500.
[3] H. A. Simon, "A behavioral model of rational choice," *Quart. J. Econ.*, vol. 69, no. 1, pp. 99–118, Feb. 1955, doi: 10.2307/1884852.
[4] P. S. Muljana, T. Luo, S. Watson, W. D. Euefueno, and K. N. W. Jutzi, "Promoting instructional designers participation in free, asynchronous professional development: A formative evaluation," *J. Formative Design Learn.*, vol. 4, no. 2, pp. 74–87, 2020, doi: 10.1007/s41686-020-00044-4.
[5] C. Hodges, S. Moore, B. Lockee, T. Trust, and A. Bond. (2020). *The Difference Between Emergency Remote Teaching and Online Learning*. EDUCAUSE Review, 3. [Online]. Available: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning
[6] A. O. Mohmmed, B. A. Khidhir, A. Nazeer, and V. J. Vijayan, "Emergency remote teaching during coronavirus pandemic: The current trend and future directive at middle east college Oman," *Innov. Infrastruct. Solutions*, vol. 5, no. 3, pp. 1–11, Dec. 2020, doi: 10.1007/s41062-020-00326-7.
[7] J. Xie and M. F. Rice, "Professional and social investment in universal design for learning in higher education: Insights from a faculty development programme," *J. Further Higher Educ.*, vol. 45, no. 7, pp. 886–900, Aug. 2021, doi: 10.1080/0309877X.2020.1827372.
[8] V. Abramenka-Lachheb, A. Lachheb, J. Leung, R. Sankaranarayanan, and G. Z. Seo, "Instructional designers' use of informal learning: How can we all support each other in times of crisis?" *J. Appl. Instructional Des.*, vol. 10, no. 3, 2021, doi: 10.51869/103/valaljlrsgs.
[9] Z. Yu, "A meta-analysis and bibliographic review of the effect of nine factors on online learning outcomes across the world," *Educ. Inf. Technol.*, vol. 27, no. 2, pp. 2457–2482, Mar. 2022, doi: 10.1007/s10639-021-10720-y.
[10] A. Istenič, "Online learning under COVID-19: Re-examining the prominence of video-based and text-based feedback," *Educ. Technol. Res. Develop.*, vol. 69, no. 1, pp. 117–121, Feb. 2021, doi: 10.1007/s11423-021-09955-w.
[11] A. Kamble, R. Gauba, S. Desai, and D. Golhar, "Learners perception of the transition to instructor-led online learning environments: Facilitators and barriers during the COVID-19 pandemic," *Int. Rev. Res. Open Distrib. Learn.*, vol. 22, no. 1, pp. 199–215, Mar. 2021, doi: 10.19173/irrodl.v22i1.4971.

[12] T.-J. Lin, "Exploring the differences in Taiwanese University students online learning task value, goal orientation, and self-efficacy before and after the COVID-19 outbreak," *Asia–Pacific Educ. Researcher*, vol. 30, no. 3, pp. 191–203, Jun. 2021, doi: 10.1007/s40299-021-00553-1.

[13] D. Calvo, "Free software meets Facebook: Placing digital platforms usage by free culture communities," *New Media Soc.*, vol. 24, no. 5, pp. 1076–1096, May 2022, doi: 10.1177/1461444820971629.

[14] Q. Conley and K. E. Sabo, "The social media instructional design model: A new tool for designing instruction using social media," *Int. J. Social Media Interact. Learn. Environ.*, vol. 3, no. 4, p. 290, 2015, doi: 10.1504/IJSMILE.2015.074008.

[15] U. Kelzang and T. Lhendup, "Relationship between Facebook usage and academic performance of college students under the Royal University of Bhutan," *J. Educ., Soc. Behavioural Sci.*, vol. 34, pp. 29–38, Apr. 2021, doi: 10.9734/jesbs/2021/v34i230303.

[16] F. Llorens and N. Capdeferro, "Facebook's potential for collaborative e-learning," *Int. J. Educ. Technol. High Educ.*, vol. 8, pp. 197–210, Jul. 2011, doi: 10.7238/rusc.v8i2.963.

[17] J. Leung, "An NLP approach for extracting practical knowledge from a CMS-based community of practice in e-learning," *Knowledge*, vol. 2, no. 2, pp. 310–336, Jun. 2022, doi: 10.3390/knowledge2020018.

[18] Access the Capability Model. (Aug. 5, 2021). *American Talent Development*. [Online]. Available: https://www.td.org/capability-model/access

[19] (Apr. 21, 2016). *Instructional Designer Competencies*. Welcome to Ibstpi. Accessed: Aug. 6, 2021. [Online]. Available: https://ibstpi.org/instructional-design-competencies/

[20] M. Florence and A. D. Ritzhaupt, "Standards and competencies for instructional design and technology professionals [E-book]," in *Design for Learning*. EdTech Books, p. 20.

[21] ISTE Standards: Educators. *ISTE (N.D.) ISTE Standards: Educators*. Accessed: Mar. 10, 2022, [Online]. Available: https://www.iste.org/standards/iste-standards-for-teachers

[22] I. Nonaka and H. Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford, U.K.: Oxford Univ. Press. 1995, doi: 10.1016/0024-6301(96)81509-3.

[23] E-Learning Industry. (N.D.) Instructional Designers. Facebook. Accessed: Mar. 21, 2022. [Online]. Available: https://www.facebook.com/groups/idesigner/about

[24] Designers for Learning. (N.D.) Facebook. Accessed: Mar. 21, 2022. [Online]. Available: https://www.facebook.com/groups/designersforlearning/about

[25] Adobe Captivate Users. (N.D.) Facebook. Accessed: Mar. 21, 2022. [Online]. Available: https://www.facebook.com/groups/834148473407485/about

[26] Articulate Storyline. (N.D.) Facebook. Accessed: Mar. 21, 2022. [Online]. Available: https://www.facebook.com/groups/287021188083419/about

[27] E. Cambria and B. White, "Jumping NLP curves: A review of natural language processing research," *IEEE Comput. Intell. Mag.*, vol. 9, no. 2, pp. 48–57, May 2014, doi: 10.1109/MCI.2014.2307227.

[28] R. Albalawi, T. H. Yeap, and M. Benyoucef, "Using topic modeling methods for short-text data: A comparative analysis," *Frontiers Artif. Intell.*, vol. 3, p. 42, Jul. 2020, doi: 10.3389/frai.2020.00042.

[29] A. Badawy, J. A. Fisteus, T. M. Mahmoud, and T. A. El-Hafeez, "Topic extraction and interactive knowledge graphs for learning resources," *Sustainability*, vol. 14, no. 1, p. 226, 2021, doi: 10.3390/su14010226.

[30] R. Egger, "Topic modelling," in *Applied Data Science in Tourism*. Cham, Switzerland: Springer, 2022, pp. 375–403, doi: 10.1007/978-3-030-88389-8_18.

[31] J. Lave and E. Wenger, "Legitimate peripheral participation in communities of practice," in *Supporting Lifelong Learning*. Abingdon, U.K.: Routledge, 2001, pp. 121–136, doi: 10.4324/9780203996287-11.

[32] H. Annabi, S. T. McGann, S. Pels, P. Arnold, and C. Rivinus, "Guidelines to align communities of practice with business objectives: An application of social media," in *Proc. 45th Hawaii Int. Conf. Syst. Sci.*, 2012, pp. 3869–3878, doi: 10.1109/HICSS.2012.297.

[33] L. Dubé, A. Bourhis, R. Jacob, and A. Koohang, "Towards a typology of virtual communities of practice," *Interdiscipl. J. Inf., Knowl. Manag.*, vol. 1, pp. 1–25, Jan. 2006, doi: 10.28945/115.

[34] D. R. Millen, M. A. Fontaine, and M. J. Müller, "Understanding the benefits and costs of communities of practice," *Commun. ACM*, vol. 45, no. 4, pp. 69–73, 2002, doi: 10.1145/505248.505276.

[35] N. Chism, *Handbook for Instructors on the Use of Electronic Class Discussion, Office of Faculty and TA Development*. Columbus, OH, USA: Ohio State Univ., 2004.

[36] P. Jenlink and A. A. Carr, "Conversation as a medium for change in education," *Educ. Technol.*, vol. 36, no. 1, pp. 31–38, 1996.

[37] N. Kelly and A. Antonio, "Teacher peer support in social network sites," *Teach. Teacher Educ.*, vol. 56, pp. 138–149, May 2016, doi: 10.1016/j.tate.2016.02.007.

[38] A. Lantz-Andersson, M. Lundin, and N. Selwyn, "Twenty years of online teacher communities: A systematic review of formally-organized and informally-developed professional learning groups," *Teach. Teacher Educ.*, vol. 75, pp. 302–315, Oct. 2018, doi: 10.1016/j.tate.2018.07.008.

[39] J. Muls, K. Triquet, J. Vlieghe, F. De Backer, C. Zhu, and K. Lombaerts, "Facebook group dynamics: An ethnographic study of the teaching and learning potential for secondary school teachers," *Learn., Media Technol.*, vol. 44, no. 2, pp. 162–179, Apr. 2019, doi: 10.1080/17439884.2019.1583670.

[40] S. Prestridge, "Categorising teachers use of social media for their professional learning: A self-generating professional learning paradigm," *Comput. Educ.*, vol. 129, pp. 143–158, Feb. 2019, doi: 10.1016/j.compedu.2018.11.003.

[41] S.-M. Pi, C.-H. Chou, and H.-L. Liao, "A study of Facebook groups members knowledge sharing," *Comput. Hum. Behav.*, vol. 29, no. 5, pp. 1971–1979, Sep. 2013, doi: 10.1016/j.chb.2013.04.019.

[42] M. Ranieri, S. Manca, and A. Fini, "Why (and how) do teachers engage in social networks? An exploratory study of professional use of Facebook and its implications for lifelong learning," *Brit. J. Educ. Technol.*, vol. 43, no. 5, pp. 754–769, Sep. 2012.

[43] P. Ractham and D. Firpo, "Using social networking technology to enhance learning in higher education: A case study using Facebook," in *Proc. 44th Hawaii Int. Conf. Syst. Sci.*, Jan. 2011, pp. 1–10, doi: 10.1109/HICSS.2011.479.

[44] J. Bernoff and C. Li, "Harnessing the power of the oh-so-social web," *IEEE Eng. Manag. Rev.*, vol. 38, no. 3, pp. 8–15, 2010.

[45] A. Abedini, B. Abedin, and D. Zowghi, "Adult learning in online communities of practice: A systematic review," *Brit. J. Educ. Technol.*, vol. 52, no. 4, pp. 1663–1694, Jul. 2021, doi: 10.1111/bjet.13120.

[46] T. M. Mai, L. T. Nguyen, T. L. Tran, and T. V. Le, "EFL teachers Facebook groups as online communities of practice: Toward configurations for engagement and sustainability," *CALL-EJ*, vol. 21, no. 3, pp. 140–158, 2020.

[47] J. Duncan-Howell, "Teachers making connections: Online communities as a source of professional learning," *Brit. J. Educ. Technol.*, vol. 41, no. 2, pp. 324–340, Mar. 2010, doi: 10.1111/j.1467-8535.2009.00953.x.

[48] C. M. Johnson, "A survey of current research on online communities of practice," *Internet High. Educ.*, vol. 4, pp. 45–60, Jan. 2001, doi: 10.1016/S1096-7516(01)00047-1.

[49] W. Peeters and M. Pretorius, "Facebook or fail-book: Exploring 'Communit' in a virtual community of practice," *ReCALL*, vol. 32, no. 3, pp. 291–306, Sep. 2020, doi: 10.1017/S0958344020000099.

[50] K. Guldberg and J. Mackness, "Foundations of communities of practice: Enablers and barriers to participation," *J. Comput. Assist. Learn.*, vol. 25, no. 6, pp. 528–538, Nov. 2009, doi: 10.1111/j.1365-2729.2009.00327.x.

[51] J. Preece, "Sociability and usability in online communities: Determining and measuring success," *Behav. Inf. Technol.*, vol. 20, no. 5, pp. 347–356, Jan. 2001, doi: 10.1080/01449290110084683.

[52] R. A. Schwier, K. Campbell, and R. Kenny, "Instructional designers observations about identity, communities of practice and change agency," *Australas. J. Educ. Technol.*, vol. 20, no. 1, pp. 1–32, Apr. 2004, doi: 10.14742/ajet.1368.

[53] T. J. Conlon, "A review of informal learning literature, theory and implications for practice in developing global professional competence," *J. Eur. Ind. Training*, vol. 28, pp. 283–295, Feb. 2004, doi: 10.1108/03090590410527663.

[54] J. R. Evans, M. Karlsven, and S. B. Perry, "Informal Learning," in *The Students' Guide to Learning Design and Research*, R. Kimmons, Ed. EdTech Books, 2018. [Online]. Available: https://edtechbooks.org/studentguide/informal_learning

[55] S. C. Yanchar and M. N. Hawkley, "Instructional design and professional informal learning: Practices, tensions, and ironies," *J. Educ. Technol. Soc.*, vol. 18, no. 4, pp. 424–434, 2015.

[56] E. Boling, H. Alangari, I. M. Hajdu, M. Guo, K. Gyabak, Z. Khlaif, and R. I. Techawitthayachinda, "Core judgments of instructional designers in practice," *Perform. Improvement Quart.*, vol. 30, no. 3, pp. 199–219, 2017, doi: 10.1002/piq.21250.

[57] H. G. Nelson and E. Stolterman, *The Design Way: Intentional Change in an Unpredictable World*. Cambridge, MA, USA: MIT Press, 2014.

[58] D. M. Steiger and N. M. Steiger, "Instance-based cognitive mapping: A process for discovering a knowledge worker's tacit mental model," *Knowl. Manag. Res. Pract.*, vol. 6, no. 4, pp. 312–321, Dec. 2008, doi: 10.1057/kmrp.2008.19.

[59] P. Johnson-Laird and R. Byrne, "Mental models website: A gentle introduction," *Recuperado*, vol. 22, 2000.

[60] R. McAdam, B. Mason, and J. McCrory, "Exploring the dichotomies within the tacit knowledge literature: Towards a process of tacit knowing in organizations," *J. Knowl. Manag.*, vol. 11, no. 2, pp. 43–59, Apr. 2007, doi: 10.1108/13673270710738906.

[61] R. Viale and A. Pozzali, "Cognitive aspects of tacit knowledge and cultural diversity," in *Model-Based Reasoning in Science, Technology, and Medicine* (Studies in Computational Intelligence), vol. 64. Berlin, Germany: Springer, 2007, pp. 229–244, doi: 10.1007/978-3-540-71986-1_13.

[62] R. Vijayan, "Teaching and learning during the COVID-19 pandemic: A topic modeling study," *Educ. Sci.*, vol. 11, no. 7, p. 347, Jul. 2021, doi: 10.3390/educsci11070347.

[63] D. Buenaño-Fernandez, M. González, D. Gil, and S. Luján-Mora, "Text mining of open-ended questions in self-assessment of university teachers: An LDA topic modeling approach," *IEEE Access*, vol. 8, pp. 35318–35330, 2020, doi: 10.1109/ACCESS.2020.2974983.

[64] F. Gurcan and N. E. Cagiltay, "Exploratory analysis of topic interests and their evolution in bioinformatics research using semantic text mining and probabilistic topic modeling," *IEEE Access*, vol. 10, pp. 31480–31493, 2022, doi: 10.1109/ACCESS.2022.3160795.

[65] T. Kim and S. Chi, "Accident case retrieval and analyses: Using natural language processing in the construction industry," *J. Construct. Eng. Manag.*, vol. 145, no. 3, 2019, Art. no. 04019004, doi: 10.1061/(ASCE)CO.1943-7862.0001625.

[66] A. Badawy, J. A. Fisteus, T. M. Mahmoud, and T. A. El-Hafeez, "Topic extraction and interactive knowledge graphs for learning resources," *Sustainability*, vol. 14, no. 1, p. 226, Dec. 2021, doi: 10.3390/su14010226.

[67] Z. Shahbazi and Y. C. Byun, "Toward social media content recommendation integrated with data science and machine learning approach for e-learners," *Symmetry*, vol. 12, no. 11, p. 1798, Oct. 2020, doi: 10.3390/sym12111798.

[68] S. Brugman. (2021). *Introduction—Pandas-Profiling 3.0.0 Documentation*. Pandas Profiling. Accessed: Aug. 6, 2021. [Online]. Available: https://pandas-profiling.github.io/pandas-profiling/docs/master/rtd/

[69] A. Mueller. (2020). *WordCloud for Python Documentation—Wordcloud 1.8.1 Documentation*. WordCloud for Python. Accessed: Aug. 6, 2021. [Online]. Available: http://amueller.github.io/word_cloud/

[70] *Natural Language Toolkit—NLTK 3.6.2 Documentation. (N.D.)*. Natural Language Processing Toolkit—NLTK. Accessed: Aug. 6, 2021. [Online]. Available: https://www.nltk.org/

[71] J. Kaur and P. K. Buttar, "A systematic review on stopword removal algorithms," *Int. J. Future Revolut. Comput. Sci. Commun. Eng.*, vol. 4, pp. 207–210, Apr. 2018.

[72] M. Gerlach, H. Shi, and L. A. N. Amaral, "A universal information theoretic approach to the identification of stopwords," *Nature Mach. Intell.*, vol. 1, no. 12, pp. 606–612, Dec. 2019, doi: 10.1038/s42256-019-0112-6.

[73] S. Lorian, *TextBlob: Simplified Text Processing—TextBlob 0.16.0 Documentation*. TextBlob: Simplified Text Processing. Accessed: Jul. 1, 2022. [Online]. Available: https://textblob.readthedocs.io/en/dev/

[74] V. Bonta, N. Kumaresh, and N. Janardhan, "A comprehensive study on lexicon based approaches for sentiment analysis," *Asian J. Comput. Sci. Technol.*, vol. 8, no. 2, pp. 1–6, Mar. 2019, doi: 10.51983/ajcst-2019.8.S2.2037.

[75] F. H. Rachman and B. S. Rintyarna, "Sentiment analysis of Madura tourism in new normal era using text blob and KNN with hyperparameter tuning," in *Proc. Int. Seminar Mach. Learn., Optim., Data Sci. (ISMODE)*, 2022, pp. 23–27, doi: 10.1109/ISMODE53584.2022.9742894.

[76] *spaCy Industrial-Strength Natural Language Processing in Python. (N.D.)*. Accessed: Aug. 6, 2021. [Online]. Available: https://spacy.io/

[77] D. M. Blei, A. Y. Ng, and M. I. Jordan, "Latent Dirichlet allocation," *J. Mach. Learn. Res.*, vol. 3, pp. 993–1022, Mar. 2003.

[78] R. Øehùøek. (2009). *Gensim: Topic modelling for humans*. Topic Modelling for Humans. Accessed: Jul. 1, 2022. [Online]. Available: https://radimrehurek.com/gensim/

[79] N. Reimers. (2021). *Pretrained Models—Sentence-Transformers documentation*. Pre-Trained Models. Accessed: Jul. 1, 2022. [Online]. Available: https://www.sbert.net/docs/pretrained_models.html

[80] M. Grootendorst. (2020). *GitHub—MaartenGr/BERTopic: Leveraging BERT and C-TF-IDF to Create Easily Interpretable Topics*. BERTopic. Accessed: Jul. 1, 2022. [Online]. Available: https://github.com/MaartenGr/BERTopic

[81] J. Devlin, M.-W. Chang, K. Lee, and K. Toutanova, "BERT: Pre-training of deep bidirectional transformers for language understanding," 2018, *arXiv:1810.04805*.

[82] J. Chang, S. Gerrish, C. Wang, J. L. Boyd-Graber, and D. M. Blei, "Reading tea leaves: How humans interpret topic models," in *Proc. Adv. Neural Inf. Process. Syst.*, 2009, pp. 288–296.

[83] F. Rosner, A. Hinneburg, M. Röder, M. Nettling, and A. Both, "Evaluating topic coherence measures," 2014, *arXiv:1403.6397*.

[84] *GitHub—Bmabey/pyLDAvis: Python Library for Interactive Topic Model Visualization. Port of the R LDAvis Package (N.D.)*. pyLDAvis. Accessed: Jul. 1, 2022. [Online]. Available: https://github.com/bmabey/pyLDAvis

[85] M. Grootendorst. *BERTopic Visualizations*. BERTopic. Accessed: Aug. 6, 2021. [Online]. Available: https://maartengr.github.io/BERTopic/index.html#citation

[86] J. Harrison, S. A. Jain, T. Dunbar, J. Gorman, and S. Varma, "Toward automated detection of phase changes in team collaboration," in *Proc. Annu. Meeting Cogn. Sci. Soc.*, 2022, pp. 1–8.

[87] S. J. Lee and T. Reeves, "Edgar dale and the cone of experience, in *Foundations of Learning and Instructional Design Technology: The Past, Present, and Future of Learning and Instructional Design Technology*, vol. 4, R. E. West, Ed. EdTech Books, 2018, Accessed: Jul. 4, 2022. [Online]. Available: https://edtechbooks.org/lidtfoundations/edgar_dale

[88] S. J. Daniel, "Education and the COVID-19 pandemic," *Prospects*, vol. 49, nos. 1–2, pp. 91–96, Oct. 2020, doi: 10.1007/s11125-020-09464-3.

[89] S. Pokhrel and R. Chhetri, "A literature review on impact of COVID-19 pandemic on teaching and learning," *Higher Educ. Future*, vol. 8, no. 1, pp. 133–141, Jan. 2021, doi: 10.1177/2347631120983481.

[90] A. Qazi, J. Qazi, K. Naseer, M. Zeeshan, S. Qazi, O. Abayomi-Alli, I. S. Ahmad, M. Darwich, B. Ali Talpur, G. Hardaker, U. Naseem, S. Yang, and K. Haruna, "Adaption of distance learning to continue the academic year amid COVID-19 lockdown," *Children Youth Services Rev.*, vol. 126, Jul. 2021, Art. no. 106038, doi: 10.1016/j.childyouth.2021.106038.

[91] J. Leung, L. A.-L. V. Ahmed, and G. Z. Seo, "Managing instructional design projects in higher education," in *A Practitioners Guide to Instructional Design in Higher Education*, J. E. Stefaniak, S. Conklin, B. Oyarzun, and R. M. Reese, Eds. EdTech Books, 2021. [Online]. Available: https://edtechbooks.org/id_highered/managing_instruction

[92] *Search Results: Instructional Design (N.D.)* OER Commons. Accessed: Jul. 4, 2022. https://www.oercommons.org/search?f.search=instructional+design&f.general_subject=&f.sublevel=&f.alignment_standard=

[93] Z. Erden, G. Von Krogh, and I. Nonaka, "The quality of group tacit knowledge," *J. Strategic Inf. Syst.*, vol. 17, no. 1, pp. 4–18, Mar. 2008, doi: 10.1016/j.jsis.2008.02.002.

[94] (2022). *EDUCAUSE Horizon Report Teaching and Learning Edition*. EDUCAUSE. Accessed: Jul. 1, 2022. [Online]. Available: https://library.educause.edu/resources/2022/4/2022-educause-horizon-report-teaching-and-learning-edition

[95] Condition of Education. (2022). *National Center for Education Statistics*. Accessed: Jul. 1, 2022. [Online]. Available: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2022144

[96] *ATD Research | ATD (N.D.) ATD Research*. Accessed: Jul. 1, 2022. [Online]. Available: https://www.td.org/atd-research

[97] Adobe. (N.D.). *Captivate Community Adobe*. Accessed: Jul. 1, 2022. [Online]. Available: https://community.adobe.com/t5/captivate/ct-p/ct-captivate?page=1&sort=latest_replies&lang=all&tabid=all&topics=label-advanced%2Clabel-audioandvideo%2Clabel-editing%2Clabel-installationandlicensing%2Clabel-advancedactions%2Clabel-branching

[98] Articulate. (N.D.). Discussion Forum. *E-Learning Heroes*. Accessed: Jul. 1, 2022. [Online]. Available: https://community.articulate.com/forums/articulate-storyline

[99] Z. Yu, "A meta-analysis and bibliographic review of the effect of nine factors on online learning outcomes across the world," *Educ. Inf. Technol.*, vol. 27, pp. 1–26, Aug. 2021.

[100] T. Shaik, X. Tao, Y. Li, C. Dann, J. McDonald, P. Redmond, and L. Galligan, "A review of the trends and challenges in adopting natural language processing methods for education feedback analysis," *IEEE Access*, vol. 10, pp. 56720–56739, 2022, doi: 10.1109/ACCESS.2022.3177752.

[101] M. A. Arqoub, N. El-Khalili, M. A.-S. Hasan, and A. A. Banna, "Extending learning management system for learning analytics," in *Proc. Int. Conf. Bus. Anal. Technol. Secur. (ICBATS)*, Feb. 2022, pp. 1–6, doi: 10.1109/ICBATS54253.2022.9759070.

[102] S. B. Dias, S. J. Hadjileontiadou, J. Diniz, and L. J. Hadjileontiadis, "DeepLMS: A deep learning predictive model for supporting online learning in the COVID-19 era," *Sci. Rep.*, vol. 10, no. 1, pp. 1–17, Dec. 2020, doi: 10.1038/s41598-020-76740-9.

[103] S. Kaddoura, D. E. Popescu, and J. D. Hemanth, "A systematic review on machine learning models for online learning and examination systems," *Peer J. Comput. Sci.*, vol. 8, p. e986, May 2022, doi: 10.7717/peerj-cs.986.

[104] D. Kem, "Personalised and adaptive learning: Emerging learning platforms in the era of digital and smart learning," *Int. J. Social Sci. Hum. Res.*, vol. 5, no. 2, pp. 385–391, Feb. 2022, doi: 10.47191/ijsshr/v5-i2-02.

[105] B. Laxmaiah, B. Ramji, and A. U. Kiran, "Intelligent and adaptive learning management system technology (LMST) using data mining and artificial intelligence," in *ICCCE*. Singapore: Springer, 2021, pp. 333–341, doi: 10.1007/978-981-16-7985-8_35.

[106] D. M. Olivé, D. Q. Huynh, M. Reynolds, M. Dougiamas, and D. Wiese, "A supervised learning framework for learning management systems," in *Proc. 1st Int. Conf. Data Sci., E-Learn. Inf. Syst.*, Oct. 2018, pp. 1–8, doi: 10.1145/3279996.3280014.

[107] C. Peng, X. Zhou, and S. Liu, "An introduction to artificial intelligence and machine learning for online education," *Mobile Netw. Appl.*, vol. 27, pp. 1–4, Mar. 2022, doi: 10.1007/s11036-022-01953-3.

[108] W. Villegas-Ch, M. Román-Cañizares, and X. Palacios-Pacheco, "Improvement of an online education model with the integration of machine learning and data analysis in an LMS," *Appl. Sci.*, vol. 10, no. 15, p. 5371, Aug. 2020, doi: 10.3390/app10155371.

[109] C. H. Huyen. (2022). *Designing Machine Learning Systems*. Accessed: Jul. 6, 2022. [Online]. Available: https://learning.oreilly.com/library/view/designing-machine-learning/9781098107956/

[110] M. Omar, S. Choi, D. Nyang, and D. Mohaisen, "Robust natural language processing: Recent advances, challenges, and future directions," 2022, *arXiv:2201.00768*.

[111] M. T. Ribeiro, T. Wu, C. Guestrin, and S. Singh, "Beyond accuracy: Behavioral testing of NLP models with checklist," 2020, *arXiv:2005.04118*.

[112] K. Goel, N. Rajani, J. Vig, S. Tan, J. Wu, S. Zheng, C. Xiong, M. Bansal, and C. Ré, "Robustness gym: Unifying the NLP evaluation landscape," 2021, *arXiv:2101.04840*.

[113] B. Rychalska, D. Basaj, A. Gosiewska, and P. Biecek, "Models in the wild: On corruption robustness of neural NLP systems," in *Proc. Int. Conf. Neural Inf. Process.* Cham, Switzerland: Springer, 2019, pp. 235–247, doi: 10.1007/978-3-030-36718-3_20.

[114] V. Krotov and L. Silva, "Legality and ethics of web scraping," in *Proc. 24h Americas Conf. Inf. Syst.*, 2018, pp. 1–5.

[115] M. Mancosu and F. Vegetti, "What you can scrape and what is right to scrape: A proposal for a tool to collect public Facebook data," *Social Media Soc.*, vol. 6, no. 3, Jul. 2020, Art. no. 205630512094070, doi: 10.1177/2056305120940703.

[116] S. A. Catanese, P. De Meo, E. Ferrara, G. Fiumara, and A. Provetti, "Crawling Facebook for social network analysis purposes," in *Proc. Int. Conf. Web Intell., Mining Semantics (WIMS)*, 2011, pp. 1–8, doi: 10.1145/1988688.1988749.

[117] A. N. Washburn, B. E. Hanson, M. Motyl, L. J. Skitka, C. Yantis, K. M. Wong, J. Sun, J. P. Prims, A. B. Mueller, Z. J. Melton, and T. S. Carsel, "Why do some psychology researchers resist adopting proposed reforms to research practices? A description of Researchers rationales," *Adv. Methods Practices Psychol. Sci.*, vol. 1, no. 2, pp. 166–173, Jun. 2018, doi: 10.1177/2515245918757427.

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Appendix 3-Article 3: Design Features of Online Teacher Professional Development: A Design Case for Re-Developing the EdHub Library to Improve Usability and Alignment of Content with Teacher Standards

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DESIGN FEATURES OF ONLINE TEACHER PROFESSIONAL DEVELOPMENT: A DESIGN CASE FOR RE-DEVELOPING THE EDHUB LIBRARY TO IMPROVE USABILITY AND ALIGNMENT OF CONTENT WITH TEACHER STANDARDS

Javier Leung, *University of Missouri*

The EdHub Library is an online teacher professional development platform that serves 250 school districts as part of the Network for Educator Effectiveness in Missouri. It has a collection of more than 300 online activities. This design case describes the efforts of re-developing EdHub due to technical and usability issues of the first generation of the content management platform. The second generation of EdHub was the product of two prototypes and two user testing sessions between January 2018–April 2018. A literature review of information-seeking habits of K-12 teachers and web design and usability standards guided the development of the second generation of EdHub to support teachers' browsing and searching behaviors. Five design decisions support the second generation of EdHub in terms of (1) priority of visual elements, (2) ease of navigation, (3) content alignment with Missouri teacher standards, (4) organization of results in the search engine, and (5) unifying learning objectives, activities, reflection, and external resources.

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INTRODUCTION

Teacher professional development (PD) is an essential aspect of continuing education and professional development of teachers' careers. Studies have shown the impact of PD on improving teaching practices and changing teachers' beliefs and attitudes. Borko (2004) describes teacher PD as a contextualized educational system that consists of a PD program, facilitators as providers of PD, and teachers as the recipients of PD.

Online platforms allow teachers to access resources and communities of practice 24/7 (Rice & Dawley, 2009). Online platforms can deliver multiple opportunities for professional development, coaching or peer-mentoring, student-focused lesson planning, and customized training materials. Research studies suggest strong evidence between teacher professional development and reflection. When teachers perform journaling self-reflection activities in professional development, teachers can critically assess their classroom practices that lead to increased student learning (Thorpe, 2004; Chitpin, 2006; Pultorak, 1993; Yang, 2009; Saylor & Johnson, 2014). With the rise of internet technologies, online platforms make online teacher professional development and self-reflection activities possible.

Along with similar online teacher professional development platforms such as PE Central and MyTeachingPartner, the EdHub Library is an online professional development platform with more than 300 online modules along with self-reflection activities that are aligned with Missouri teacher standards (Hanson, Pennington, Prusak & Wilkinson, 2017, MyTeachingPartner, 2017). This paper describes the efforts for developing the second iteration of the EdHub Library based on user testing sessions of prototypes, review of the research literature of teachers' information-seeking habits, and specific platform usage findings related to EdHub users.

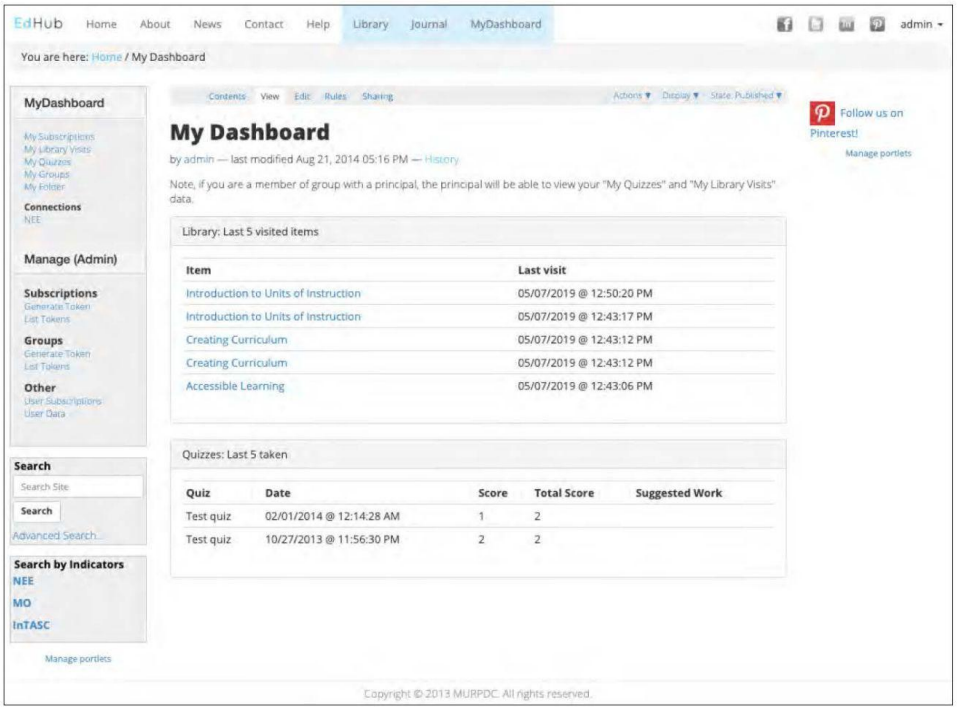

FIGURE 1. EdHub Generation 1 School Administrator Dashboard.

CONTEXT

EdHub is the online professional development component of the Network of Educator Effectiveness (NEE) at the University of Missouri. NEE is a comprehensive system that tracks multiple measures of educator effectiveness to support teacher growth through classroom observations, student and teacher surveys, and yearly teacher observation training sessions for school administrators. The EdHub Library was initially funded by the Bill and Melinda Gates Foundation in 2014 in partnership with the University of Missouri. Since 2014, my responsibilities include (1) collaborating with subject matter experts on content writing, (2) developing self-paced modules and face-to-face training, (3) maintaining and deploying materials, and (4) implementing web analytics across the platform.

NEE school districts have access to (1) a video library of best practices in classroom teaching, (2) a video library of examples for scoring classroom observations, (3) a catalog of self-paced online modules, (4) copyrighted assessment instruments, (5) journal reflection activities, and (6) yearly calibration training sessions for school administrators. EdHub provides online professional development resources on a wide variety of topics for teachers and instructional leaders that support instructional practices based on indicators of teacher effectiveness.

The first generation of the EdHub platform was built on an open-source content management platform called Plone. On the EdHub platform, users registered for an account using their school email address to access online professional development, journal features, an administrator and teacher dashboards, as shown in Figure 1. In the EdHub platform, teachers and administrators were organized by the school district. School administrators could observe teacher activity and read journal entries when teachers shared their journals with administrators.

When searching for professional development in the first generation of the platform, users could either browse resources from the homepage directory or search for materials tagged by teacher standards. Each activity contained a voluntary journal activity that teachers might choose to complete and share with school administrators.

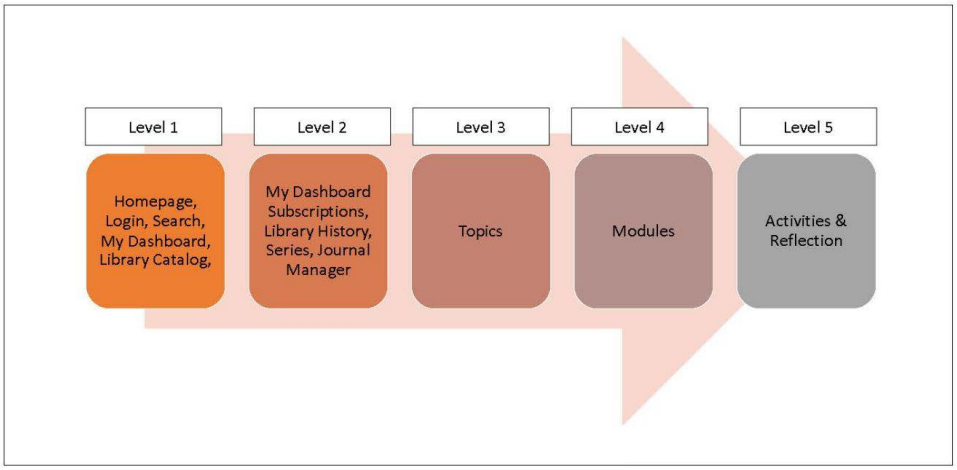

FIGURE 2. Five-Level Sequential Navigation of EdHub Generation 1.

Three types of learning objects are available in EdHub, including (1) self-paced materials, (2) open lessons that don't require login credentials, and (3) blended activities. The EdHub Library team is composed of two Instructional Designers who develop professional development materials in-house. The professional development materials are aligned with teacher standards in collaboration with NEE trainers and subject matter experts.

Design Motivation

The motivation for redesigning the library from the ground up was to (1) improve usability of the site, including structure, navigation, and content access in order to facilitate efficient navigation of resources without additional logins or user permissions, and (2) improve the site's privacy, as users had expressed concern about the visibility and sharing of their journal reflection entries with other school districts on the platform.

A survey was sent to approximately 300 school districts in 2016 asking for feedback from Missouri teachers in terms of their frequency of use, alignment of EdHub content with their PD needs, and barriers related to access. Even though the survey response rate from teachers was approximately five percent, survey results were consistent with the feedback from school administrators who attended mandatory in-person training sessions. The feedback from the teacher survey and in-person training sessions from administrators shared common areas of improvement as follows:

1. To improve navigation and usability of the site
2. To make the platform accessible to all schools without login and user registration
3. To eliminate privacy and sharing issues over teacher reflection
4. To maintain the platform and content within the department

To Improve Navigation and Usability of the Site

Responses from the 2016 survey showed that school districts experienced technical challenges in accessing the EdHub Library. The majority of responses involved simplifying login and navigation requirements that allowed them to navigate relevant materials related to their professional development planning, units of instruction development, and student lesson planning.

The first generation of the platform had several navigation issues and five levels of access for navigating instructional modules. Platform features (Search, My Dashboard, Library Catalog, and Journal) were accessible from the homepage as the primary navigation menu. Navigation issues were present in the Library Catalog that contained all instructional modules organized by topics, modules, and activities/reflection. The navigation of the Library Catalog could only be accessed in a sequential structure without giving users the ability to skip sections.

For example, users accessed content topic modules located at the fourth level from the Library Catalog homepage. As users navigated through the series, topics, modules, and activities, users became overwhelmed by the number of descriptions for each section. The series or instructional themes

described the overall summary of the topics within the series. Also, the alignment of professional development and teacher standards was not present until users navigated to the modules. The navigation prevented users from properly assessing materials and their alignment with teacher standards. Even though the first generation of EdHub provided a breadcrumb menu to help users to understand their location in the library, the menu became lengthy as users navigated to module sections. Figure 2 shows the sequential navigation of the first iteration of the EdHub platform.

With the implementation of the sequential navigation structure, users found the information overwhelming as they navigated through the series, topics, modules, and activities. The navigation structure prevented users from browsing the entire catalog and searching for specific pieces of professional development. Also, users could only use the left menu to navigate the site and perform search functions. In video demonstration 1, the user performed several steps to access a module's overview, activities, and resources in three separate pages.

Video demonstration 1. EdHub Generation 1 Navigation Challenges.
https://media.dlib.indiana.edu/media_objects/5t34t258n

To Make the Platform Accessible to All Schools Without Login and User Registration

After signing up for an account on TheEdHub.org, users entered group and content tokens that allowed them to access their assigned school districts and designated professional development materials. Users were required to enter two tokens or access codes. First, users entered the group token that placed teachers in their respective school districts. Second, users entered a content token to control access to different types of materials based on their role and employment status. Without these codes, registered users could not access any of the content, features, and school districts.

Also, the content codes allowed principals and teachers to access different types of materials. For example, school administrators had access to the entire catalog of professional development and principal training materials. In contrast, teachers had access to the whole professional development catalog except for principal training materials and copyrighted indicator rubrics.

Although users did not experience issues with entering the access code for their assigned school districts, users experienced issues with entering the access code for professional development materials. In most cases, teachers copied and pasted the access code for materials with blank spaces from the registration email that caused EdHub to warn users of an invalid access code. Teachers who moved to new school districts needed two new access codes for their respective schools and professional development materials. However, teachers who changed school districts could not migrate their journal entries and user activity to their new school districts.

To Eliminate Privacy and Sharing Issues Over Teacher Reflection

In the first iteration of the EdHub Library, teachers expressed their concern with the lack of full privacy controls over journal entries based on the 2016 survey and on-site training sessions. The journal feature in EdHub allowed teachers to record their professional development activities and lesson planning.

As teachers worked on their journal entries, teachers set their journals as draft status that could only be viewed by them. Once teachers completed their journal entries, teachers had the option to set journals private or publish them as public on the platform that was available to all registered users regardless of school district. Teacher feedback identified the need for full control over journal entries by allowing them to publish their journal entries to selected individuals within a school district group. Even though the EdHub staff and school administrators were unable to see private journal entries, NEE decommissioned the journal feature due to potential liability.

Although the first iteration of EdHub intended to create a community of practice that allowed sharing of materials within a school (e.g., sharing units of instructions among teachers of the same subject matter), an additional layer of privacy was required for sharing journal entries with specific individuals.

Due to time constraints and limited resources, the journal feature was not incorporated in the second generation of EdHub. Instead, teachers could download the journal template from the homepage. Also, teachers were responsible for sharing with their supervisors and storing their journal entries.

To Maintain the Platform and Content Within the Department

The first iteration of the EdHub Library was developed by a third-party vendor in Missouri, Practical Concepts Consulting, using an open-source content management system called Plone. Although Plone was a highly customizable platform that handled user permissions and content access, the finalized production version of the library had issues related to navigation, privacy, and user and access permission settings.

These issues prevented users from engaging with the journal feature and navigating to professional development materials. For EdHub administrators, the platform could not handle uploading and maintaining multimedia assets and external links. With this particular limitation on the web

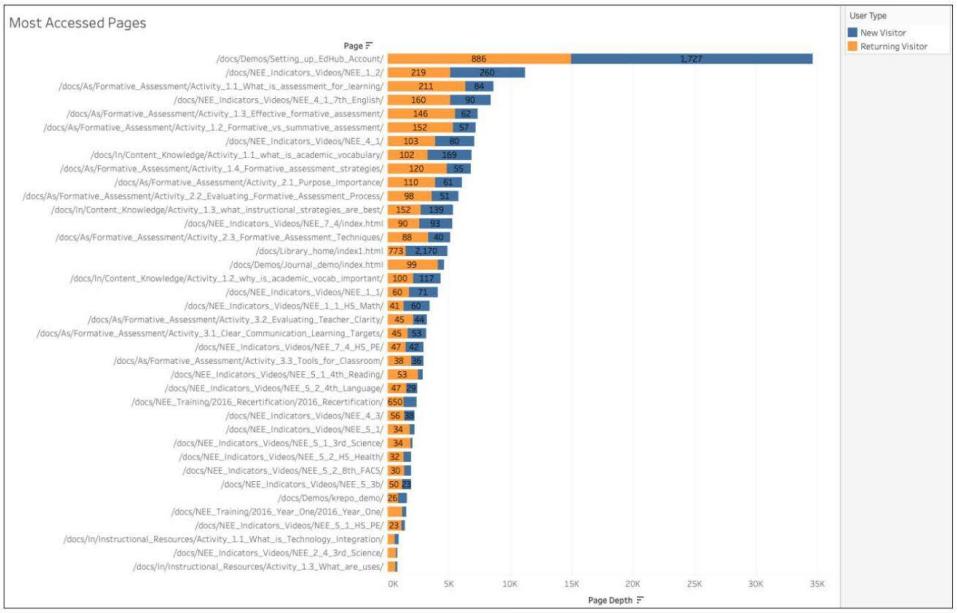

FIGURE 3. Most accessed pages in EdHub Generation 1.

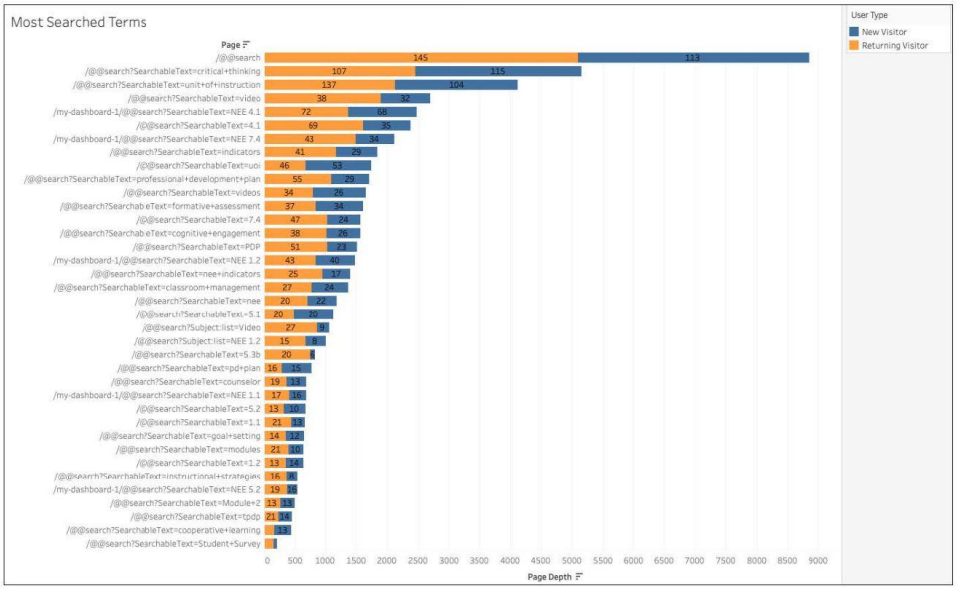

FIGURE 4. Most searched terms in EdHub Generation 1.

storage, multimedia assets were hosted outside the platform to accommodate web traffic.

Even though the platform would have required external funding to fix the platform's user access settings and privacy controls of the journal feature, the first iteration of EdHub also needed a significant overhaul to improve navigation and search of materials. At the time of my employment in 2014, the platform was already in use without any user and technical testing.

In December 2018, the platform was decommissioned in favor of an embedded version of EdHub within the NEE Data Tool that required no additional logins and worked within the existing process of collecting teachers' classroom observation data.

Design Decisions and Literature Review on Teachers' Search Habits

In October 2015, the free version of Google web analytics in the first iteration of EdHub provided stakeholders with information about users' library navigation and login patterns. Although the free version of Google Analytics generated rich data about users (e.g., page views and time on page) and their point of access (e.g., NEE Data Tool or EdHub domain), Google Analytics did not track IP addresses, personal identifiable information, or contents of teachers' journal artifacts.

The web analytics data showed that users navigated to activities related to EdHub how-tos, assessment, rubric implementation, and principal training materials from October 2015 to February 2017 (Figure 3). Even though these activities were required during the on-site training sessions in the summer and at the beginning of the school year, there were little to no page views for other activities available in the library.

In Figure 4, web analytics of the first generation of EdHub showed that users performed specific searches related to teacher indicators (e.g., NEE 4.1 for student problem-solving and critical thinking, NEE 7.4 for monitoring effect of instruction) and particular processes for professional development (e.g., TPDP or teacher professional development plan). Interestingly, users performed search queries using teacher indicators (e.g., 1.1, 1.2, 5.1) rather than entering actual words for different areas of teacher professional development. Also, users performed specific search queries related to professional development processes such as units of instruction, classroom observation videos, professional development plans, and student surveys.

In a specific study related to the first iteration of EdHub, I performed a clustering analysis of web analytics data to derive use cases and navigation patterns of new and returning visitors. Four out of seven navigation patterns indicated that new and returning users accessed EdHub through the NEE Data Tool (Leung, 2018).

New and returning school administrators accessed the site to review group and content access codes, user profile preferences, reset passwords, and reviewed teachers' journal entries. Also, new and returning school administrators accessed mandatory training related to recertification and classroom observation processes. New and returning teachers accessed the site to perform journal tasks and accessed materials related to cognitive engagement, affective engagement, and assessment.

By exploring the web analytics data, feedback from training sessions, and support calls, the redesign of the EdHub Library incorporated five design decisions during development and testing of prototype A and B. The design decisions accounted for two types of users who would use the second generation of EdHub. First, users (e.g., first-year teachers) who were new to professional development did not fully understand teacher indicator alignment or individuals (e.g., library specialists, paraprofessionals, speech coaches, and instructional coaches) who assisted teachers and did not use teacher indicators in their roles. Second, users (e.g., tenured teachers and school administrators) who were seasoned teachers and understood how to search for standards-based professional development.

The design decisions stemmed from three sources: (1) web analytics data of the first generation of EdHub, (2) 2016 teacher survey, and (3) feedback from mandatory training sessions of school administrators. The overarching goal of the design decisions was to support users with multiple ways of searching and browsing professional development within a familiar environment (i.e., NEE Data Tool) regardless of professional development experience. The following design decisions were based on the literature of teachers' information-seeking behaviors and Nielsen's heuristics for user-interface design.

Design Decision 1: Prioritize Visual Elements

In user interface design, Nielsen (1994) articulated general or broad principles for interaction design that included (1) visibility of system status, (2) match between the system and real world, (3) user control and freedom, (4) consistency and standards, (5) error prevention, (6) recognition rather than recall, (7) flexibility and efficiency of use, (8) aesthetic and minimalist design, (9) help users recognize, diagnose, and recover from errors, and (10) help and documentation. More specifically to teachers' information behaviors, Limberg (1999) identified three major patterns of teachers' variation of information-seeking habits in the areas of fact-finding, choosing the right information, and analyzing and scrutinizing information.

Even though the first generation of the platform did not meet Nielsen's heuristics in terms of consistency and standards, recognition rather than recall, and aesthetic and minimalist design, the redesign of EdHub emphasized the implementation of the aftermentioned heuristics principles that helped both non-experienced and experienced users with consistent interface experiences.

These consistent interface experiences involved previewing all topics from the library homepage and their alignment with teacher indicators, accessing instructional modules in two (e.g., using the search engine or teacher indicator sitemaps) or three steps (e.g., navigating from the homepage, topic list, and module), and recognizing the location of materials with consistent breadcrumb navigation available in all pages of the library.

The first generation of EdHub did not prioritize the organization and preview of the library catalog and its contents. This issue prevented users from assessing the usefulness and navigation of instructional modules. Also, the content alignment to teacher indicators was not evident as users navigated sequentially to instructional modules. The second generation of EdHub allowed users to assess the contents of topics with consistent arrangements from the homepage to the desired professional development module. This decision benefited non-experienced users who were casually browsing topics on the homepage without a specific topic or standard.

As shown in video demonstration 2, prototype A organized the EdHub Library in three sections (getting started, search engine feature, and topic categories). In video demonstration 3, prototype B of the EdHub homepage was reorganized in the four main sections in a vertical view starting with the getting started section, search engine feature, indicator sitemaps, and topic categories organized in alphabetical order.

Video demonstration 2. Homepage EdHub Generation 2 Prototype A.
https://media.dlib.indiana.edu/media_objects/5d86ph68v

Video demonstration 3. Homepage EdHub Generation 2 Prototype B.
https://media.dlib.indiana.edu/media_objects/np193t51b

Design Decision 2: Ease of Navigation Across All Levels

In the first iteration of the platform, a common characteristic between new and returning teachers and administrators groups was the increased web traffic to web pages that listed all resources by teacher indicators (Leung, 2018). Even though the library offered around 300 activities, users did not access other areas of the library, such as teacher-student communication, data analysis, Common Core State Standards, and Next Generation Science Standards, and family and community involvement.

This decision aimed to improve the information architecture of EdHub by changing the navigation structure and information presentation. In the second generation of EdHub, the navigation structure changed from a sequential navigation scheme to a hierarchical structure. The hierarchical structure allowed users to navigate the library in three steps or less with consistent alignment with teacher indicators. Unlike the first generation of EdHub, the information presentation of topics was consistent across the homepage, topics, and modules.

For non-experienced and experienced users, the homepage of the second generation of EdHub provided consistent overviews of teacher indicator alignment and overviews of the topics and their content. At the topic level, topics were organized based on the topic's previews from the homepage with precise alignment to teacher indicators. At the module level, learning objectives, activities, reflection, and resources were organized consistently and aligned with teacher indicators. In video demonstration 4 of prototype A, a topic category was organized into subtopic categories with relevant descriptions and a filter option to search by term. In video demonstration 5 of prototype A, a module provided users with a single point of access to objectives, activities, tasks, and resources.

Video demonstration 4. Level 2: Topics EdHub Generation 2 Prototype A.
https://media.dlib.indiana.edu/media_objects/xw42ns53g

Video demonstration 5. Level 3: Modules EdHub Generation 2 Prototype A.
https://media.dlib.indiana.edu/media_objects/3t946830n

Design Decision 3: Search Materials with Sitemaps Across Multiple and Individual Teacher Standards

With increased web traffic to indicator pages in the first generation of EdHub, this design decision was carried over to the second generation of EdHub with changes to the navigation that allowed for user input within the lists to filter materials by keyword or indicator. In the first generation of EdHub, the sitemaps required two pages to list all resources by teacher indicators. In the second generation of EdHub, the sitemaps were single pages that provided direct access to instructional modules by indicating the alignment and location of materials.

The sitemaps presented a clear benefit in terms of narrowing the information-seeking needs of users. According to Shipman (2015), teachers most frequently looked for instructional design of lesson plans, exercises, assessment tools, and action research topics related to teaching. While sitemaps provide users with the ability to narrow their choices, sitemaps might provide users with a certain level of confidence in finding professional development aligned with indicators. Williams and Coles (2007) argued that teachers expressed

less confidence in their information literacy abilities for finding and evaluating research-based information related to teaching.

The second generation of the EdHub Library provided different types of training modules, including classroom observation video examples, self-paced instructional modules, examples of units of instruction, face-to-face training materials, and classroom observation self-assessment activities.

With teacher indicator sitemaps in the second generation of EdHub, users were able to find specific professional development with alignment to indicators regardless of the type of professional development activity. This design decision benefited experienced users looking for targeted professional development by teacher standards. In video demonstration 6 of prototype B, indicator sitemaps allowed users to navigate to a full list of instructional modules by browsing the list by indicator or entering terms to narrow module topics of interest.

Video demonstration 6. EdHub Search by Indicator Generation 2 Prototype B.
https://media.dlib.indiana.edu/media_objects/7w62fs60c

Design Decision 4: Search Materials with a Search Engine and Provide Query Results Organized by the Homepage Topic Structure

Using a search engine to find information is a common feature across websites. Kundu (2015) reported that teachers preferred using a search engine over printed materials for locating professional development topics. Limberg and Sundin (2006) said that teachers' information-seeking approaches were both user-oriented and context-dependent when searching for subject-specific and general information applicable to several contexts and applications in the classroom.

While teacher indicator sitemaps were characterized by context-dependent searches based on users' information needs of teacher indicators, the search engine also allows for user-oriented information tasks based on keywords of interest. The search engine feature enabled non-experienced users to locate materials across multiple topics and modules without fully understanding the alignment with teacher standards.

The search engine results were presented with a similar topic structure from the EdHub homepage across multiple topics. For example, the search term "technology" displayed in the search engine results across several topics in Indicator Classroom Exemplars, Communication, Beginning Teacher Assistance Instructional Strategies, and Professional Practices. In video demonstration 7 of prototype B, the search engine feature allowed users to search modules across multiple topics with their respective topic category.

Video demonstration 7. EdHub Search Engine Generation 2 Prototype B.
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Even though this design decision was implemented across the homepage, topic, and module in prototype A, the user testing showed that users had display issues when searching at the topic and module-level due to the lack of adequate space on the top right of the page. In prototype B, the search engine was only available on the homepage that provided proper space for previewing and navigating search results.

Design decision 5: Create a Single Point of Access for Learning Objectives, Activities, and External Resources

In the first generation of EdHub, instructional modules were in three separate pages. For example, users navigated sequentially to reach the external resources and used the back button in the browser or breadcrumb menu to return to the previous page. In the second generation of EdHub, the components of an instructional module are logically laid out in a single page in three distinct segments, including learning objectives, activities and tasks, and resources. The bookmark navigation menu at the top of the module allowed users to navigate to different sections of the instructional module.

According to Ermeling (2010), Joyce and Showers (2002), and Peery (2002), teachers preferred looking for instructional solutions with immediate improvement in student outcomes. By presenting the entire instructional module, the alignment of content to teacher indicators was evident at the beginning of the module. It also allowed non-experienced and experienced users to make judgments if a particular material addressed their professional development needs. In video demonstration 8 of prototype B, instructional modules were kept with the similar organizational structure based on prototype A, but the search engine at the module level was eliminated due to display issues.

Video demonstration 8. Level 3: Modules EdHub Generation 2 Prototype B.
https://media.dlib.indiana.edu/media_objects/3j333m030

PROJECT DESCRIPTION AND TEAM MEMBERS

Before developing and testing prototypes of EdHub, the NEE team suggested that the professional development materials could be hosted in Canvas learning management system (LMS) in early September 2017. As a cost-saving measure, migrating EdHub materials to Canvas LMS would leverage existing resources with minimal downtime. Even though I mocked up and tested an alternative interface of the library in Canvas and similar systems, several challenges were as follows:

1. The linear sequence of modules did not support searching of content across multiple indicators.
2. The linear sequence of modules did not support the browsing of content at a high level to provide a bird's-eye view of what is available in the library. The content cannot be easily explored using a modular approach.
3. The lack of search engine support within Canvas prevented users from locating modules across several topics and indicators.
4. Logins for non-student members were not allowed at the university at the time.
5. Course quotas did not accommodate the large number of resources already on EdHub. The complexity and lack of tracking changes of multimedia learning objects within a Canvas course shell could be easily broken when moving assets between folders and directories.

To overcome the limitations of Canvas, I developed a prototype as a standalone version of the EdHub Library using Bootstrap, Cascading Style Sheets (CSS), and HTML. This project also incorporated a third-party search engine called SiteSearch360 that allowed for customized indexing of web resources, keyword dictionaries, and search results previews (SiteSearch360, n.d.).

The redesign project consisted of four phases for 11 months from initial meetings for phasing out the first generation of EdHub to the final communication of the availability of the second version of EdHub to all school districts.

The team consisted of two Instructional Designers (one developer and one subject-matter expert), five NEE trainers, and one director. I was responsible for developing the prototypes and keeping track of changes. I was also the Instructional Designer accountable for maintaining and deploying the platform. Table 1 describes a summary of project events in developing and testing the second generation of the platform.

Overall, the second generation of EdHub encapsulated five design decisions in the development and testing of two prototypes and two user testing sessions: (1) visual priority of elements, (2) ease of navigation, (3) browsing materials by teacher indicators, (4) searching across multiple content

1. EDHUB GENERATION 2 REQUIREMENTS	
October 2017	• Migrate content to a new webserver • Meet with internal stakeholders for phasing out EdHub Generation 1 • Establish a timeline for EdHub Generation 1 phasing out
November 2017	• Meet with IT for integrating EdHub Generation 2 into an existing tool • Meet with internal stakeholders to prioritize essential functions of EdHub
December 2017	• Announce phasing out of EdHub Generation 1 to all school districts
2. EDHUB GENERATION 2 PROTOTYPE & TESTING	
January 2018	• Prototype initial idea by incorporating five design decisions: Visual priority, navigation, browsing by indicators, searching across content, and unifying module, activities, tasks, and resources in one page.
February 2018	• Conduct user testing with trainers of prototype A in a test environment • Complete content migration to the new server
March 2018	• Incorporate feedback from prototype A for improving search engine results organization
April 2018	• Create an MS Word of the journal template • Conduct user testing with trainers and external participants on prototype B in the test environment • Finalize technical testing of prototype B in the production environment
3. EDHUB GENERATION 2 DEPLOYMENT	
May 2018	• Deploy EdHub Generation 2 for Summer Training 2018 in the production environment • Perform adjustments to user tutorials per user feedback from training sessions
August 2018	• Communicate deployment of EdHub Generation 2 to all school districts
4. EDHUB GENERATION 1 PHASE-OUT	
December 2018	• Phase out EdHub Generation 1

TABLE 1. Summary of Project Milestones.

topics, and (5) consolidating module activities, resources, and reflection within a single page.

Phase 1: EdHub Generation 2 Requirements

In October 2017, the NEE team held several meetings to discuss phasing out the first generation of EdHub. The group also discussed finding a new web hosting service for storing multimedia assets and instructional materials that could accommodate substantial web traffic of 35,000 users based on web analytics data (Leung, 2018). In November and December 2017, internal stakeholders and IT staff discussed the possibility of embedding EdHub within the existing Data Tool that collected classroom observation scores and student surveys. Accessing the library within the Data Tool was a priority for stakeholders since it would eliminate the need for teachers to remember login credentials and access tokens for groups and content.

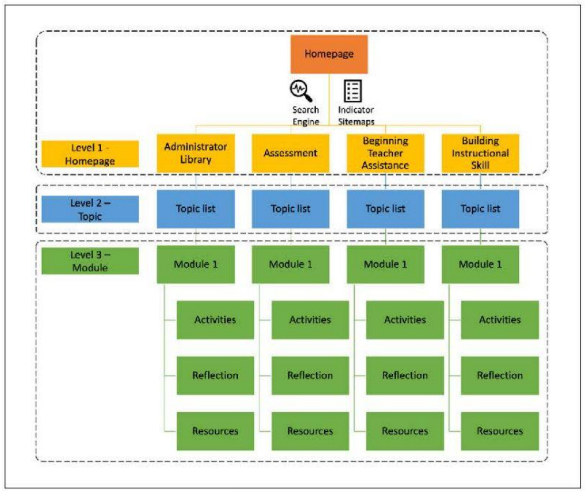

FIGURE 5. Three-Level Hierarchical Structure of EdHub Generation 2.

We also discussed the platform's elements that were required for teachers to provide easier access and navigation to professional development materials. Due to the lack of funding and expertise in Plone development, platform features, such as journals, administrator dashboard, and content and group access codes, did not need further development by IT staff. NEE notified users about the phasing out of the platform and asked users to download any journal entries from the old platform until December 2018.

Phase 2: EdHub Generation 2 Prototype and Testing

During the prototype and user testing phase in January–February 2018, I developed prototype A of the EdHub homepage that contained relevant information about getting started, bookmarks, news, and curated content sections. Users could glance over topics available from the homepage. When a module was selected from the topic list, users had the entire module organized in three clear headings as objectives, activities, and resources.

The critical differences between prototype A and the first iteration of the EdHub involved (1) collapsing five levels of sequential navigation down to three hierarchical levels, (2) prioritizing important information first in clear sections that allowed users to look at overviews of all topics, (3) presenting content alignment and consistency with teacher indicators at all levels, and (4) encapsulating module information in a single page without having to navigate each section.

By implementing a hierarchical or tree structure in the prototype, users began with broader categories of information. They then drilled down to specific topics and modules to find more detailed information. Unlike the sequential structure, the hierarchical structure allowed for efficient navigation in and out of topics and modules, as shown in Figure 5. It also incorporated breadcrumbs throughout the library to indicate the location of materials and facilitate navigation.

In the first user testing session in March–April 2018, five trainers were given full access to prototype A of EdHub. These five users were trainers for NEE who had not previewed the prototype, but were aware of the navigation challenges of the first iteration of EdHub. Participants were given written instructions about any obstacles in performing eight tasks for locating and browsing professional development modules.

These tasks included looking for materials under an hour related to (1) Instructional Videos related to Indicator 7.4, (2) Cognitive Engagement, (3) Evaluation of School Counselor, (4) Beginning Teacher Assistance, (5) Critical Thinking, (6) Professional Development related to Indicator 5.3, (7) Units of Instruction Examples, and (8) a module of their choice. For each task, participants were asked to check whether they were able to find the module with their location in the library, write down any suggestions or challenges during the task, and provide overall feedback for the entire user experience.

Although all participants were able to perform all tasks in prototype A under 30 minutes with their correct locations of the materials, two pieces of feedback were related to the visual elements and search

functions of the homepage. User feedback also indicated display issues with search engine results at the topic and module levels. More specifically, users suggested the following items incorporated in the homepage for the next prototype.

1. Change the location of the search bar function and gold boxes (getting started and bookmarks), to the bottom of the EdHub logo
2. Eliminate News and Curated content sections
3. Reduce the size of the EdHub logo to make the Getting Started section more prominent
4. Add a Social bookmark section
5. Eliminate the search engine feature at the topic and module level due to screen size constraints
6. Improve the presentation and organization of search engine results to reflect content groups on the EdHub homepage
7. Organize the homepage in four logical sections and accommodate different ways to look for content as follows:
    a. Providing getting started information and the journal template for download
    b. Presenting search engine results by topic
    c. Browsing by teacher indicators using dedicated sitemaps
    d. Browsing topics in alphabetical order

With significant changes to the homepage layout and search engine results display, the old prototype became prototype B that incorporated dedicated pages for displaying all professional development materials by teacher indicators. Four significant sections of the EdHub homepage were displayed in prototype B by prioritizing the overview of the topic contents available in the library, as shown in Figure 6.

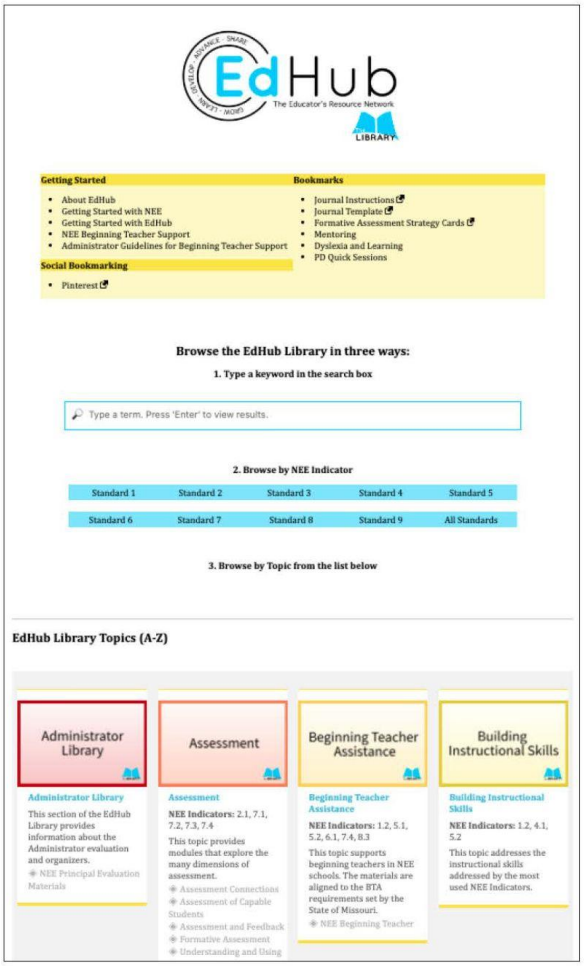

FIGURE 6. Reorganization of the EdHub Homepage Prototype B.

These prominent sections of the homepage included (1) information on getting started and mandatory training modules, (2) locating materials using a search engine, (3) browsing lists of materials by teacher indicators, and (4) browsing all available topics with previews of topics and alignment with teacher indicators.

With prototype B deployed in the test server, the second user testing session included the five NEE trainers from the first user testing session of prototype A. The same group of testers helped to verify the improvements and identify further navigation challenges. In addition to the NEE trainers, three participants outside NEE at the Assessment Resource Center (ARC) volunteered to participate in the second user testing session.

These outside participants had not seen the prototypes and had no experience with teacher professional development. A total of 8 participants were given instructions with eight preselected topics different from the first user testing session. Participants were asked to check if they were able

to locate the topic, jot down the location of the material, and provide specific feedback or challenges for each task. Participants were also asked to indicate the search method of their choice using the search engine, sitemaps, or the Edhub homepage topic list.

While the five NEE trainers performed all tasks successfully under 20 minutes using teacher indicator sitemaps and provided positive feedback for the changes implemented in prototype B, the outside participants spent around 30-40 minutes locating topics by browsing the EdHub homepage and using the search engine. However, the external participants did not use the sitemaps because of the lack of familiarity with teacher indicators. To verify the correctness of the tasks, I checked the users' responses to the materials' location.

The overall user feedback in prototype B indicated (1) the ease of readability of the library homepage with clear previews of topics and alignment, (2) user choice for searching materials by indicator, search engine, or browsing the homepage, (3) the ease of use in accessing desired materials, and (4) general awareness in recalling the location of modules in the library.

Although five outside participants responded to the recruitment call, two participants were unable to attend the sessions due to scheduling issues. Also, the user testing sessions did not contain the journal template. The template was a Microsoft Word document with blank spaces for entering teacher reflection that was not necessary for performing tasks during user testing sessions.

Nielsen and Launder (1993) noted that 75-99% of usability problems could be detected with five users. While the user testing sessions met the minimum number of participants with experienced and non-experienced users based on Nielsen and Launder's recommendation, it would have been possible to generate additional insights related to usability of the platform and users' information needs by recruiting additional external users with no prior knowledge or experience in teacher professional development.

Towards the end of the prototype and testing phase in April 2018, prototype B was finalized with minor tweaks to topic titles based on the second user testing session. In collaboration with the IT team, prototype B was embedded in the production server within the NEE Data Tool using the iframe HTML tag. In the technical testing of the library, the IT team discovered that the display height of EdHub did not render correctly in the production server.

The height of EdHub collapsed to the height of the menu options in the Data Tool, which was around 400 pixels in height. Even though the iframe code of EdHub in the test environment displayed adequately, the iframe code required additional height and width parameters of 600 pixels and 100 percent, respectively. With these parameters, the height of EdHub was preserved within another resource by overriding the custom CSS properties of the Data Tool in the production server.

Phase 3: EdHub Generation 2 Deployment

Once the display issue was fixed in the production server, the second generation of EdHub was ready to roll out for Summer Training in May 2018. These training sessions served two goals. First, the training provided principals with practice opportunities for scoring classroom observations of teachers available in the EdHub Library. Second, the training sessions allowed principals to get acquainted with the second generation of EdHub.

In training surveys, principals highlighted (1) the ease of navigation and location of professional development materials using a variety of search methods, (2) the ability for curating targeted materials by teacher indicators, (3) the ability to preview the alignment of teacher indicators and materials in the homepage and search engine results, and (4) the inclusion of video tutorials for teachers on EdHub.

In August 2018, NEE communicated the full transition of the EdHub Library to all school districts at the beginning of the new school year. NEE also reminded school districts to download any journal entries and documents in the first version of EdHub.

Phase 4: EdHub Generation 1 Phase-Out

In December 2018, the first generation of EdHub was defunct in favor of an embedded version of EdHub in the NEE Data Tool. At this point, I rolled out how-to video tutorials for teachers and migrated all instructional modules to the new web hosting service. Even though the first generation of EdHub was not accessible after the implementation of the new platform, an archive was created to keep copies of web analytics data of instructional modules and user access for a future analysis between the two versions of EdHub.

CONCLUSION

Online teacher professional development platforms enable teachers to access resources remotely and plan for professional growth based on self-identified professional development needs or recommended by their school administrator. While teachers' professional needs and experience with professional development vary significantly, this design case specifically explores the process of redesigning online teacher professional development and testing two prototypes with experienced and non-experienced users.

Even though the second generation of EdHub supports user-oriented and context-dependent information-seeking needs of users using state teacher standards in a fully online

environment, this design case may not be applicable to other forms of online teacher professional development structures that do not rely on teacher standards and hybrid or web-enhanced delivery methods. While professional development can be developed in traditional learning management systems (LMS), the linear presentation of information may not be adequate for users to assess context-specific tasks of aligning teacher standards with professional development modules.

In this design case, the feedback from teachers and administrators emphasized the need to improve EdHub in terms of (1) navigation and usability, (2) ease of access, (3) ensuring user privacy of teacher reflection, and (4) in-house maintenance of the library. The second generation of the EdHub Library was refined through two user testing sessions that ensured a clear separation and prominence of the sections in the homepage to support experienced and non-experienced users. Also, the navigation scheme was restructured from five levels of sequential steps to three steps using a hierarchical structure. The hierarchical structure allowed for better navigation and assessment of materials with teacher standards at all levels of the library.

The design decisions implemented in the second generation of EdHub support the self-regulation activities of teachers and school administrators in their acquisition of professional development. Self-regulation refers to the process of monitoring progress, checking outcomes, and redirecting unsuccessful efforts while participating in the learning process (Zimmerman, 2002). Self-regulation activities involve multiple techniques for evaluating and monitoring learning, including, self-monitoring, self-instruction, goal setting, and self-reinforcement.

As users consciously apply cognitive, metacognitive, and motivation strategies to their learning environment, Edhub enables teachers of various self-regulating capacities to locate professional development materials by using the search engine, indicator sitemaps, or homepage topic directory while assessing the alignment of materials to teacher standards during their information-seeking task.

While the EdHub Library features a redesigned hierarchical navigation structure and several ways to help teachers and school administrators to locate materials based on teacher standards, EdHub accommodates different types of user-oriented and context-dependent information-seeking tasks.

In user-oriented tasks, for example, new teachers are able to locate materials curated to their PD needs under the Beginning Teacher Assistance topic from the EdHub homepage. EdHub also provides a dedicated section in the homepage for practicing classroom observation scoring evaluation activities that provide principals and assistant principals with on-demand training simulations of classroom observations with immediate corrective feedback.

In context-dependent tasks, the EdHub Library supports building leaders in locating PD resources that fit school district goals by using teacher standards sitemaps. For subject-specific materials, for instance, math teachers are able to use the search engine to locate materials that target multiple topics in student engagement, formative assessment, classroom observation, and examples of units of instruction. While EdHub accommodates the individual needs of users, EdHub helps collaborative groups to curate materials using the search engine that organizes search engine results by topic category.

Finally, the design case benefits developers of online platforms and designers of teacher professional development by creating an understanding of user needs in online K-12 settings. For example, developers of online platforms are able to support teachers' information-seeking with effective navigation schemes and better affordances of web interfaces. Designers of teacher professional development materials are able to understand the implications of teachers' information needs and information architectures in standards-based PD.

Even though the second generation of EdHub supports various types of users and information tasks, further research within the EdHub Library design case is required in understanding self-regulation activities and information-seeking preferences (e.g., search engine, teacher standards sitemap, homepage directory) among teachers and school principals of various degrees of professional development needs and experience.

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REFERENCES

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational researcher*, *33*(8), 3-15. https://doi.org/10.3102%2F0013189X033008003

Chitpin, S. (2006). The use of reflective journal keeping in a teacher education program: A Popperian analysis. *Reflective practice*, *7*(1), 73-86.

Ermeling, B. A. (2010). Tracing the effects of teacher inquiry on classroom practice. *Teaching and teacher education*, *26*(3), 377-388. https://doi.org/10.1080/14623940500489757

Hanson, A., Pennington, T. R., Prusak, K., & Wilkinson, C. (2017). PE Central: A Possible Online Professional Development Tool. Physical Educator, 74(3), 570. https://doi.org/10.18666/TPE-2017-V74-I3-7352

Joyce, B. R., & Showers, B. (2002). Student achievement through staff development (3rd ed.). Association for Supervision & Curriculum Deve (ASCD).

Kundu, D. K. (2015). Nature of the Information Seeking Behaviour of Teachers Engaged in General Degree Colleges and Teachers' Training Colleges: A Critical Analysis. *Athens Journal of Education*, *2*(3), 257-273. https://doi.org/10.30958/aje.2-3-6bv

Leung, J. (2018). Discovering Utilization Patterns in an Online K-12 Teacher Professional Development Platform: Clustering and Data Visualization Methods. *Quarterly Review of Distance Education*, 19 (3), 17-37. https://eric.ed.gov/?id=EJ1205884

Limberg, L. (1999). Three conceptions of information seeking and use. *Exploring the contexts of information behaviour*, 116-135.

Limberg, L., & Sundin, O. (2006). Teaching information seeking: relating information literacy education to theories of information behaviour. *Information Research: an international electronic journal*, *12*(1), n1. https://eric.ed.gov/?id=EJ1104682

MyTeachingPartner. (2017). Retrieved from https://curry.virginia.edu/myteachingpartner

Nielsen, J. (1994). Usability inspection methods. In *Conference companion on Human factors in computing systems* (pp. 413-414). https://doi.org/10.1145/259963.260531

Nielsen, J., & Landauer, T. K. (1993). A mathematical model of the finding of usability problems. In *Proceedings of the INTERACT'93 and CHI'93 conference on Human factors in computing systems* (pp. 206-213). https://doi.org/10.1145/169059.169166

Peery, A. (2002). Beyond inservice. Principal Leadership, 3(3), 22-28.

Pultorak, E. G. (1993). Facilitating reflective thought in novice teachers. *Journal of Teacher Education*, *44*(4), 288-295. https://doi.org/10.1177%2F0022487193044004007

Rice, K., & Dawley, L. (2009). The status of professional development for K-12 online teachers: Insights and implications. Journal of Technology and Teacher Education, 17(4), 523-545. https://www.learntechlib.org/primary/p/28226/

Saylor, L. L., & Johnson, C. C. (2014). The role of reflection in elementary mathematics and science teachers' training and development: A meta-synthesis. *School Science and Mathematics*, *114*(1), 30-39. https://doi.org/10.1111/ssm.12049

Shipman, T. (2015). In-Service Teachers and their Information-Seeking Habits: Does Library Instruction Show a Relationship to Information-Seeking Habits for Professional Use? *National Teacher Education Journal*. http://hdl.handle.net/11200/48519

SiteSearch360. (n.d.). SiteSearch360. Retrieved July 31, 2020, from https://www.sitesearch360.com/

Thorpe, K. (2004). Reflective learning journals: From concept to practice. *Reflective practice*, *5*(3), 327-343. https://doi.org/10.1080/14623940420002706 55

Williams, D., & Coles, L. (2007). Evidence-based practice in teaching: an information perspective. *Journal of documentation*.

Yang, S. H. (2009). Using blogs to enhance critical reflection and community of practice. *Journal of Educational Technology & Society*, *12*(2), 11-21. https://www.jstor.org/stable/10.2307/jeductechsoci.12.2.11

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into practice*, *41*(2), 64-70. https://doi.org/10.1207/s15430421tip4102_2

VITA

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