Developing an Ontology to Explore Competencies Needed by Instructional Design Professionals in Higher Education

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This multi-strategy research study aimed to develop an initial formal ontology of competencies needed by instructional design professionals in higher education. The ontology was constructed using a formal ontology design process and then validated by eight expert instructional design professionals in higher education using an online survey. The quantitative responses showed a general agreement with the ontology. Three themes emerged from the qualitative data: an expansion of instructional design competencies, the addition of a diversity, equity, and inclusion competency, and the removal of the programming competency. The

findings are discussed, and proposed changes to the ontology are provided.

Introduction

Instructional designers play a critical role in learning by assisting educators with creating educational materials. For many instructional design professionals, this reality includes structuring curricula, designing or redesigning courses, creating learning materials, assisting with implementation, and evaluating student and program outcomes. Instructional designers are tasked with developing effective, engaging, and efficient learning experiences using systematic design processes and technology to facilitate learning and improve performance.

Competencies of Instructional Design Professionals

Instructional designers require a wide range of competencies to support instructors and students. A competency refers to "a knowledge, skill, or [ability] that enables one to effectively perform the activities of a given occupation or function to the standards expected in employment" (Richey et al., 2001, p.8). Such actions can range from acquiring specific knowledge the person needs to know, to skills they need to perform on the job, to abilities they have to perform an activity or task.

Professional associations and researchers are working to identify the competencies required by professionals in the field. Several professional associations have developed competency models that determine the knowledge, skills, and abilities instructional designers need to design instruction and competency frameworks that define professional performance criteria. Researchers have investigated competencies for instructional designers (Klein & Kelly, 2018; Larson & Lockee, 2004; Martin & Ritzhaupt, 2020) by using a variety of research methods, including a review of job postings and announcements (Kang & Ritzhaupt, 2015; Klein & Kelly, 2018; Moallem, 1995; Sugar et al., 2012; Sumuer et al., 2006; Wakefield et al., 2012), interviews with expert instructional designers (IDs) (Klein & Kelly, 2018; Ritzhaupt & Kumar, 2015), online surveys (Iqdami & Branch, 2016; Ritzhaupt et al., 2018; Ritzhaupt & Martin, 2014), and Delphi studies collecting consensus decisions amongst experts (Brill et al., 2006; Daniels et al., 2012; Thach & Murphy, 1995).

The International Board of Standards for Training, Performance, and Instruction [IBSTPI] (2023) produced competency standards by identifying foundational research, drafting competencies, and validating and rewriting based on that process. However, the development process for this organization was last completed in 2012 (IBSTPI, 2023). Since then, the number of technical and instructional design competencies professionals need to have likely grown as technology and process have changed, especially with the growth of learning management systems, media inclusion, and accessibility requirements. In addition,

there remains a lack of clarity around which foundational research was included for review or the validation process for included IBSTPI competencies, and these are focused on professional corporate instructional designers rather than those working in higher education. Further, no formal ontology development process grounded in an accepted definitional and structural approach was included in this organization's approach to allow for external validation and revision, leaving a gap of knowledge in the field of applied instructional design.

In higher education settings, instructional design professionals are expected to have a wide range of competencies including solid communication and soft skills (Chongwony et al., 2020; Klein & Kelly, 2018; Magruder et al., 2019; Ritzhaupt & Kumar, 2015; Wakefield et al., 2012; Wang et al., 2021), knowledge of instructional design and learning theories (Kang & Ritzhaupt, 2015; Klein & Kelly, 2018; Ritzhaupt & Kumar, 2015; Ritzhaupt & Martin, 2014; Sugar et al., 2012; Tennyson, 2001), knowledge of multiple forms of technology (Kang & Ritzhaupt, 2015; Klein & Kelly, 2018; Kumar & Ritzhaupt, 2017; Ritzhaupt & Kumar, 2015; Wang et al., 2021), provide professional development to various stakeholders (Kumar & Ritzhaupt, 2017; Magruder et al., 2019; Park & Luo, 2017; Ritzhaupt et al., 2018; Ritzhaupt & Kumar, 2015), and manage multiple projects simultaneously (Chongwony et al., 2020; Kline et al., 2020; Ritzhaupt et al., 2018; Sumuer et al., 2006; Surrency et al., 2019). However, much of the literature lists competency names without providing clear, explicit examples or definitions. This situation can be confusing and ambiguous for individuals looking for specific definitions of competencies required by instructional designers. A formal, unambiguous, explicit representation of competencies would eliminate confusion and demonstrate complex interrelations between competencies.

Ontologies

Ontologies provide a way to share and reuse knowledge across people and systems (Arp et al., 2015). According to Corcho et al. (2003), there are many ways to formalize knowledge, organize class and relation hierarchies, and characterize tasks and inferences. However, to achieve a shareable and reusable knowledge base, vocabularies of representational terms with the agreed-upon definitions must be constructed. Ontologies should be developed consistently, involving varied data and information, and be adjusted over time to reflect the current state of the domain (Arp et al., 2015).

The first definitions of ontologies were often vague and could be interpreted in many ways, harming their utility and consistent use. Gruber (1993) is among the first to define the notion of an ontology as an "explicit specification of a conceptualization (p. 1)." Over the years, many definitions have been modified and derived from this description. For example, Arp et al. (2015, p.1) proposed an alternative definition of an ontology to include "a representational artifact, comprising a taxonomy as a proper part, whose representations are intended to designate some combination of universals, defined classes, and certain relations between them." This definition provides more guidance and details for what an ontology is.

Ontologies can be developed in several ways (Corcho et al., 2003); however, there is no up-to-date comprehensive methodology for ontology development (Keet, 2020). Many research groups apply their methods for constructing ontologies due to the lack of details provided by other research groups on the development process. Although there are different methods to

create an ontology, there are usually accepted stages in which an ontology is built. These include a.) identifying the purpose and scope, b.) determining the terms and the relationships, c.) defining terms and organizing them into hierarchies, d.) writing the formal model in a way that others have access to the ontology, and e.) maintaining the ontology over time (Pinto & Martins, 2004).

Arp et al. (2015) proposed a systematic and coherent five-step process to build an ontology. Each phase is iterative and involves successive reviewing cycles to ensure information represents the reality of a given domain. These phases can be summarized as (1) defining the subject matter, (2) gathering relevant information, (3) provisional ordering of the terms, (4) systematically regimenting the domain information, and (5) formalizing the ontology in a computer-useable language. When this process is followed, the terminological content of a specific topic can be coded in such a way as to ensure widespread accessibility and useability.

Ontologies are used successfully in various contexts, including education, which often uses ontologies to formulate a representation of a learning domain by specifying all the concepts involved, the relationships between the concepts, and the properties and conditions that exist (Grivokostopoulou et al., 2019). Specifically, ontologies are used in higher education across various applications, including curriculum development, e-learning, academic recommendations, and others (Tapia-Leon et al., 2018).

One application of higher education not represented by ontologies is instructional design competencies. Due to the nature of their work, instructional design professionals must have a wide range of competencies to succeed. Hundreds of competencies are listed in the research and design literature. At the same time, professional organizations such as the AECT and IBSTPI continue organizing the growing lists of instructional design competencies. However, due to the sheer number of competencies and the fact that most competencies are not clearly defined, there remains confusion about what competencies are necessary and how they are all related.

Explicit descriptive representations of competencies in these ontologies should eliminate confusion and demonstrate the relationships among the competencies needed for instructional design professionals in higher education institutions. Ontologies can also provide a practical framework that is easily intelligible by individuals reviewing competencies for hiring, benchmarking competencies for professional development opportunities, or educational programs preparing people for the field. Another benefit is that competencies can be added, removed, or modified quickly in the ontological framework, providing a glimpse of the current reality of competencies needed by instructional design professionals in higher education.

This study aimed to develop an initial formal ontology of competencies needed by instructional design professionals in higher education. To accomplish this task, the process involved outlining the competencies necessary for instructional design professionals, defining each competency, creating an initial formal ontology, and having domain experts evaluate the ontology's accuracy in representing the competencies required by instructional design professionals in higher education.

Methods

This multi-strategy, grounded theory study (Robson & McCartan, 2016) sought to identify the competencies needed by instructional design professionals in higher education. Central to this study was constructing a formal ontology (Arp et al., 2015) to define instructional designer competencies using a multi-strategy data collection approach that leveraged survey-based perception, demographics, and interview data drawn from higher education instructional design professionals to ensure properly contextualized, evidence-based findings (Robson & McCartan, 2016). This ontology provided a representational artifact that included formal naming and definitions of competencies. The framework also explained relationships among the categories of competencies.

Following ontology development, domain experts, in this case higher education instructional design professionals, were used to validate the ontology. Domain experts used an online survey to determine how well the ontology represented competencies they believed were needed by instructional design professionals in higher education settings. Feedback from domain experts was used to revise the hierarchy of terms and definitions to ensure logical and scientific adequacy, thus enhancing the reliability of the developed formal ontology. This ontology is intended for use by academics and professionals in the field of instructional design, and its development included a thorough validation process to ensure its reliability and usefulness in practice.

Ontology Development

The first step in the Ontology Design Process outlined by Arp et al. (2015) was to define the subject matter of the ontology, which included the scope of the ontology. Limiting the research to professionals in higher education settings allowed the researcher to identify competencies and definitions in a specific context and validation from experts in the field. This study did not define all competencies needed by instructional design professionals in the field; instead, it defined common competencies required in higher education. It also did not provide a suggested list of competencies for professionals to succeed in their positions; this study provided a comprehensive list of competencies stated by professional organizations and academic literature.

The second step in the ontology development process was gathering relevant information from the academic literature, which included journal articles and conference proceedings focusing on the competencies of instructional design professionals within a higher education setting. Keywords such as competency, competencies, job responsibilities, instructional designers, curriculum developers, educational technologist, higher education, college, and university were combined to make multiple database queries. Scopus and EBSCOhost databases were used to collect articles and conference proceedings. It is worth noting that EBSCOhost allowed the researcher to search over 100 databases at one time, including Academic Search Complete, Business Source Complete, Professional Development Collection, and more. One hundred seven peer-reviewed articles were initially identified. Sources that included one of the following were excluded from the ontology development: duplicate papers of the same study in different repositories, papers outside higher education settings, papers mentioning competencies for instructional design

managers, papers that did not list competencies, papers not written in English, books and book chapters, reviews, introductory papers for special issues, and technical reports. Fifteen articles met the inclusion criteria, including 12 academic journal articles and three conference proceedings. The 15 articles included 1,127 competencies.

Additionally, competencies for instructional designers stated by the Association of Educational and Communication Technology (AECT), the Association for Talent Development (ATD), the International Board of Standards for Training Performance and Instruction (IBSTPI), and the International Society for Performance Improvement (ISPI) were included to provide competencies from multiple sources. Professional organizations listed 102 competencies. To the researchers' knowledge, no ontology mentioned competencies needed for instructional design professionals; therefore, no additional competencies were reviewed.

The academic literature and professional organizations identified 1,229 competencies, of which 744 were exact duplicates. The remaining 485 competencies were organized into similar groups (e.g., communication, production skills, instructional design models, etc.) and reviewed to identify similarities. In many cases, different articles listed the same competency but described them differently. For example, Wang et al. (2021) stated needs assessment, while Klein and Kelly (2018) stated conduct a needs assessment. There were 384 similar competencies removed.

The remaining 101 competencies were reviewed to determine whether similar competencies could be combined. In several cases, similar competencies were able to be combined. For example, spreadsheet software (e.g., Excel), presentation software (e.g., PowerPoint), and word processing software (e.g., Word) were combined to form Microsoft Office Tools. In this phase of the review process, 63 competencies could be combined with other competencies to avoid redundancies. Combining similar competencies left 38 for Step 3 of the development process.

The third step in the ontology development process was to provisionally order the competencies in a hierarchy from general to specific. Of the 38 competencies, four competencies were identified as general competencies or the root nodes: instructional design, technology, support, and professionalism. These competencies provided the initial starting points for the hierarchy. The remaining 34 competencies were placed in the taxonomic hierarchy listed from general to specific under corresponding root nodes.

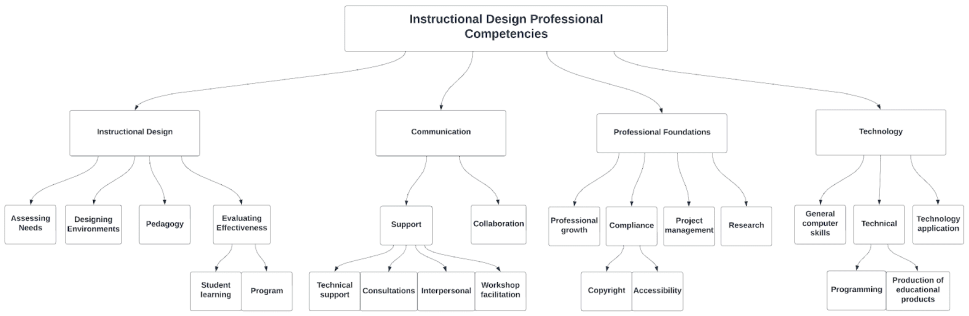
The fourth step in the ontology development process was to regiment the results. This step involves successive cycles of reviewing the hierarchy to ensure information is logically coherent, unambiguous, and as true to the facts of reality as possible. During the initial review, three competencies (i.e., audio, video, and games/simulations) were not considered typical for all instructional design professionals and, therefore, removed from the hierarchy. Each competency was then defined precisely, scientifically accurately, and understandably. Competencies at the top of the hierarchy were first defined, then others followed, working downward through the hierarchy toward more specific competencies. As definitions were developed, the researcher continued to review the preliminary classification scheme, considering any changes that the definitions dictated. Eight changes in the hierarchy occurred – namely, the combination of competencies due to similar definitions. After all

competencies were defined, additional review cycles were required to ensure the ontology was structured around an is_a hierarchy because the child node is an example of the parent node. This approach ensured ontological agreement between terms and their parents. For example, the evaluation of program outcomes and the evaluation of student learning were both instances of evaluating effectiveness, which was an instance of instructional design competency. The iterative and successive cycles of reviewing the hierarchy resulted in 27 competencies being included in the final ontology.

The final step in the ontology development process was to formalize the ontology so users can better understand, maintain, and update the ontology knowledge. Ontologies are typically shared with others using a computer-useable language such as Web Ontology Language 2 (WOL 2). However, due to the complicated nature of these editing programs, a visualization of the ontology was formally produced using Lucid Chart, a diagramming program. Then, a list of the definitions was created in a Microsoft Word document to make it easier for domain experts to provide feedback. Figure 1 provides the final version of the ontology.

Figure 1

Domain Ontology for the competencies needed by Instructional Design professionals



Evaluation from Experts

Participants

Purposive sampling was utilized to select domain experts to review the ontology. Expert instructional design professionals who currently or have worked in higher education settings for at least five years, held an instructional designer or related position, preferably managed other instructional design professionals, and contributed academically and/or professionally to the field of instructional design were asked to participate in the study.

Eleven potential participants were contacted and recruited through e-mail. Nine participants responded to the email; however, one was excluded due to no previous experience working in a higher education institution. Eight expert instructional design professionals served as domain experts. Table 1 presents demographic data regarding each of the eight domain experts.

Table 1

Demographic information for each domain expert

Name	Experience	Job Title	Education Institution	Supervisor
Kaden	5-7 years	Instructional designer, associate instructor	Public university	Yes
Mae	11 - 15 years	Learning & Development Manager	Public university	No
Dean	8 - 10 years	Sr. Instructional Designer	Private university	No
Jameson	5 - 7 years	Learning Design Team Manager	Public university, Community College	Yes
Elena	11 - 15 years	Instructional Designer, Supervisor, Director	Public university	Yes
Sadie	11 - 15 years	Instructional Designer	Public university, Private university, Community College	Yes
Areigh	5 - 7 years	Instructional Designer, Executive Director of Student Learning	Public university, Community College, Vocational	Yes
Gracie	5 - 7 years	Director State Initiatives	Public university	Yes

Online Surveys

The online survey was developed to validate the ontology. The information collected in the online surveys was anonymized, and domain experts were given pseudonyms to protect their identities. The survey included a mixture of 4-point Likert-scale and open-ended questions that allowed domain experts an opportunity to provide their expert opinions, comments, and feedback on the ontology's terminology, definitions, and structure.

Responses from the Likert-scale questions were analyzed using Excel functions to obtain frequencies and descriptive statistics. Responses for open-ended questions were analyzed using a constant comparative method (Strauss & Corbin, 1990). Open coding was used in the first coding round to identify relevant meaning units in the data. The second round of coding used axial coding to determine connections between the categories or the clustering of themes. The final round of coding determined themes that emerged from the data.

Findings

Using the Ontology Design Process outlined by Arp et al. (2015), the researcher developed an initial formal ontology that provided a common understanding of competencies needed by instructional design professionals in higher education settings. Domain experts validated the ontology to ensure it represented the competencies required by instructional design professionals. Online surveys were used to gather feedback from domain experts on the ontology's competencies, definitions, and structure.

Quantitative findings

Domain experts were asked to indicate their agreement or disagreement with statements regarding terminology, definitions, and structure of the ontology by selecting one of four choices: (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree. Of the 193 quantitative responses recorded across the terminology, definition, and structure statements, the domain experts generally “agreed” (101 responses) or “strongly agreed” (56 responses) with the statements. The remaining 35 responses “disagreed” with various statements, while one response “strongly disagreed” with the hierarchy having is_a relations between the nodes.

The information provided by domain experts related to terminology (Table 2) presents a general agreement in the competencies used in the ontology. The average for all the items was 3.313, meaning domain experts “agreed” that the competencies were selected correctly for the ontology. Five domain experts “strongly agreed,” and the remaining three “agreed” that the competencies used in the ontology are essential and relevant for instructional design professionals to have. The least commonly agreed-on item was competencies in this ontology are common for instructional designers to have. Three domain experts “disagreed” that the competencies were common, while five “agreed” with the statement. Although there was some variation in responses for the two items, domain experts generally agreed with the competencies presented in this ontology.

Table 2

Domain experts indicated their agreement or disagreement with statements related to terminology

Item	Mean	Variance	Standard Deviation	Minimum	Maximum
Used by influential groups/scientists	3.750	0.214	0.463	3	4
Important for IDs to have	3.625	0.268	0.518	3	4
Common for IDs to have	2.625	0.268	0.518	2	3
Specific	2.875	0.410	0.641	2	4
Relevant	3.625	0.268	0.518	3	4

Item	Mean	Variance	Standard Deviation	Minimum	Maximum
Describes reality	3.375	0.268	0.518	3	4

The information provided by domain experts related to definitions (Table 3) includes a general agreement with the definitions provided for the competencies used in the ontology. The average for all the items was 3.286, meaning domain experts "agreed" with the definitions used in the ontology. The item definitions are coherent and had the most variability in responses from domain experts, with one participant disagreeing, four agreeing, and two strongly agreeing with the statement. Overall, the domain experts agreed with the definitions provided for the competencies in the ontology.

Table 3

Domain experts indicated their agreement or disagreement with statements related to definitions

Item	Mean	Variance	Standard Deviation	Minimum	Maximum
All competencies have definitions	3.571	0.286	0.534	3	4
Include essential features	3.143	0.143	0.378	3	4
Non-circular	3.286	0.238	0.488	3	4
Easy to understand	3.286	0.238	0.488	3	4
Simple terms	3.286	0.238	0.488	3	4
Logical	3.286	0.238	0.488	3	4
Coherent	3.143	0.476	0.690	2	4

The information provided by domain experts related to the structure (Table 4) resulted in a general agreement with the structure of the ontology. The average for all the items was 3.18, meaning domain experts "agreed" with the structure of the ontology. Other items in the structure question had higher levels of variability than in the previous terminology and definition questions. For example, the item is_a relations between nodes showed the highest rate of variance (0.982) and standard deviation (0.991), meaning responses ranged from "strongly disagreed" to "strongly agreed."

Table 4

Domain experts indicated their agreement or disagreement with statements related to structure

Item	Mean	Variance	Standard Deviation	Minimum	Maximum
Organized from general to specific	3.375	0.554	0.744	2	4
Ordered in a logical way	3.500	0.286	0.533	3	4
Each child node is connected to one parent node	3.500	0.286	0.533	3	4
Each child node is characteristic of the parent node	3.125	0.696	0.835	2	4
Each sibling node in the hierarchy has the same generality.	3.125	0.696	0.835	2	4
Is_a relations between nodes	2.875	0.982	0.991	1	4
Hierarchy is complete	2.750	0.500	0.707	2	4

Qualitative findings

The domain experts were asked a series of open-ended questions centered around the terminology, definitions provided, and the general structure of the ontology. While coding the qualitative data that was used to help contextualize the quantitative, survey-based responses, three themes emerged, including expanding instructional design competencies, adding diversity, equity, and inclusion competencies, and removing the programming competency. The open-ended item responses were used to contextualize and help explain the survey-based data used to produce quantitative findings and statistical outcomes.

Expansion of instructional design competencies

Domain experts recommended expanding the instructional design section to better represent the competencies needed by instructional design professionals in higher education. Several experts recommended adding instructional design models to the competencies. However, specific instructional design models were not mentioned. The domain experts also suggested emphasizing the importance of getting to know the learners and learning environment for assessing needs competency. Kaden noted that “something about understanding the learning landscape, conditions, and learners themselves” should be

stated in the ontology. Other recommendations included moving accessibility and copyright under designing learning environments to clarify the important role both accessibility and copyright play in content development.

Addition of Diversity, Equity, and Inclusion competencies

Domain experts recommended the addition of a diversity, equity, and inclusion (DEI) competency for instructional design professionals in higher education. As Sadie mentions, a DEI competency would "apply thoughtful pedagogical means to support students from different backgrounds and with various needs." This competency provides a more student-centered approach to building belonging in virtual and physical classrooms. Although there was an agreement among domain experts on the addition of a DEI competency, the location of the competency in the ontology was unclear. Dean mentioned EDI could be added under Designing Environments due to the importance of designing learning environments with DEI. Still, it could also fall under Professional Foundations due to the importance of weaving DEI initiatives in all aspects of an instructional design professional's job. Sadie explained that DEI could be included "under communication/Support and also under pedagogy as it has become more important than ever to design with DEI." From the participant feedback, a DEI competency is needed; however, the location of the competency in the ontology would require a formal definition of DEI to be created.

Removal of programming competencies

Nearly all the domain experts preferred removing programming competencies from the ontology. From their professional experience, programming was not a necessary competency for instructional design professionals in higher education settings. Some domain experts, such as Sadie, mentioned that "programming is not very important," while Elena stated, "coding languages haven't been something that has been required." In both cases, from their personal experience, programming has not been needed; therefore, it does not represent the realities of instructional design professionals working in higher education settings.

Discussion and Conclusion

This ontology development study sought to explore competencies needed by instructional design professionals in higher education settings. From the academic literature and professional organizations in the field, instructional design professionals are required to have a wide range of competencies to be successful in their positions. The sheer number of competencies coupled with the fact that most competencies are not clearly defined leave many managers and designers in the field confused as to what competencies are necessary and how they are all related. One way to address this growing concern is to formalize knowledge in a shareable and reusable way, such as a domain ontology.

An initial formal domain ontology was constructed using the Domain Ontology Design Process of Arp et al. (2015), which included multiple phases of data collection and iterative

review cycles. The resulting domain ontology represented competencies needed by instructional design professionals in higher education settings. Eight domain experts validated the ontology using an online survey. Results indicated the domain experts agreed with the terminology used in the ontology, definitions of the competencies, and the general structure of the ontology. Although there was overall agreement in the ontology, domain experts recommended an expansion of the instruction design competencies, adding a DEI competency and removing the programming competency to better represent the competencies needed by instructional design professionals in higher education settings.

While this ontology offers an overview of the competencies required by instructional design professionals in higher education, these competencies are subject to change as information, technology, and professional contexts evolve. This implies a limitation on the relevance and utility of the ontology over time, necessitating ongoing maintenance and updates to reflect new developments in knowledge and practice. Another possible limitation of this study is that, while the ontology was focused on higher education, it may not encompass all aspects of the domain. Domains are often intricate and multifaceted, making capturing every facet of the ontology challenging. In future studies, it may be helpful to consider how an ontology that represents the competencies of instructional design professionals could be used as an assessment tool to identify gaps in performance and knowledge. This ontology could be beneficial at the organizational level to ensure consistent and explicit competencies between instructional design professionals and the organization/institution. Perhaps more critical could be the implications at the individual level. Ontologies could be used as a self-performance assessment tool for novice and experienced instructional design professionals to evaluate their current performance level, identify performance gaps, and perceive training needs to close the knowledge gap.

This study's unique contribution is the first known ontology to represent the competencies needed by instructional design professionals in higher education settings. This ontology provides a current representation of the competencies and an efficient way to share and reuse information across the field. It was designed to promote greater consistency in the description of data. Thus, the competencies were defined and organized in an ontology to provide a common data access mode.

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