

Modeling of Skills, Abilities, Competences, and Related Dispositions in the Occupation Ontology

Finn Wilson^{1,2,3,*}, Matthew A. Diller⁴, Robin McGill⁵, Sam Smith⁶, Jie Zheng⁶,
Clarissa Savluchinske Feio Vieira⁷, William D. Duncan³, John Beverley^{1,2,8} and Yongqun He⁶

¹University at Buffalo, Buffalo, NY, USA.

²National Center for Ontological Research, Buffalo, NY, USA.

³College of Dentistry, University of Florida, Gainesville, FL, USA.

⁴Division of Intramural Research, National Library of Medicine, National Institutes of Health, Bethesda, MD, USA.

⁵Alabama Commission on Higher Education, AL, USA.

⁶University of Michigan Medical School, Ann Arbor, MI, USA.

⁷NTT Data, Brussels, Belgium

⁸Institute for Artificial Intelligence and Data Science, Buffalo, NY, USA.

Abstract

There are many terms used by organizations that collect occupation-related data to refer to what job-seekers can do, including: skill, ability, capability, knowledge, and competence. These terms are often poorly defined and used interchangeably or inconsistently. In this study, we have identified and ontologically defined these and other related terms for inclusion into the Occupation Ontology (OccO), a reference ontology scoped to the broad domain of occupations and nearby phenomena. Our research provides a systematic account of disposition classes related to occupations, thereby supporting occupation data modeling and integration of disparate data structures.

Keywords

Competence, Skill, Ability, Knowledge, Occupation, Job, Occupation Ontology (OccO), Basic Formal Ontology (BFO)

1. Introduction

Many states, federal governments, and non-governmental institutions are invested in matching potential workers to jobs they are well-equipped to succeed in. For example, the US Department of Labor manages O*NET as a database for occupational information [1]. Multiple US states make use of the Credential Engine, which helps to formally structure credential information [2]. The State of Alabama implemented the Alabama Talent Triad which offers a skills-based talent marketplace [3]. And European Skills, Competences, Qualifications and Occupations (ESCO) is a terminology for this domain [4]. These organizations use various terms when collecting data related to what people can do, including ‘skill’, ‘ability’, ‘competence’, ‘capability’, and ‘knowledge’. The definitions offered for the above terms are often unclear or imprecise, leading to confusion within organizations on how to organize data and difficulty integrating data between organizations. The same labels are often used to represent subtly different concepts, making it difficult to combine datasets for useful data analysis. For example, groups sometimes distinguish between skills and abilities without making the division between them fully clear [5, 6]. Some make no sharp distinction between skills and abilities, either making them synonyms or overlapping classes, while others treat these as mutually exclusive classes, with skills being trained and abilities being innate. Similarly, some groups treat competences as sets of skills, knowledge, etc. [7], and others describe them as capabilities people have in virtue of possessing various skills, knowledge, etc. [8, 9]. This paper is concerned with resolving the above confusion. Specifically, we extend previous

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*Corresponding author.

✉ finnwils@buffalo.edu (F. Wilson)

ORCID [0009-0002-7282-0836](https://orcid.org/0009-0002-7282-0836) (F. Wilson)



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work on the Occupational Ontology (OccO) [10, 11, 12], an ontology designed for modeling occupation-related data in a standardized way, in the interest of supporting robust skills-based systems and allowing for greater interoperability across domains.

In 2022 researchers began developing OccO in the interest of connecting existing English-language occupational standards (e.g., the US Bureau of Labor Statistics Standard Occupational Classification [13], the International Standard Classification of Occupations [14], and the European Skills, Competences, Qualifications and Occupations Classification [4]) within a uniform, community-based ontological framework extending from the Basic Formal Ontology (BFO) [15]. From inception, OccO has been a collaboration between ontologists and occupation data subject matter experts. In [10] we introduced, motivated, and tested the effectiveness of OccO. This was done by comparing how occupation-related classes are organized in OccO with how they are presented in Wikidata. Because Wikidata classes are not structured according to a standardized terminology or upper-level framework, it produces confusing and incoherent results, such as ‘pharmacist’ being both a subclass of ‘health professional’ and ‘other health professional’, as well as an instance of ‘health profession’ and ‘occupational group according to ISCO’, the latter being implied to be a type of label, rather than a professional. By contrast, OccO’s ontological framework allows ‘pharmacist’ to be neatly placed as a subclass of ‘healthcare diagnosing or treating practitioner’. We also significantly expanded on the core of OccO in [11] to include terms corresponding to those found in O*NET and ESCO and information from Wikidata. And in [12] we further expanded OccO to cover terms related to credentials, due to their importance in matching job-seekers to job roles that suit them. Over the last three years, OccO has evolved to include in-depth semantic representations of occupation-related terminology. For example, we have included **Occupation Activity**: “A process in which an occupation holder participates that realizes either an occupation disposition or occupation role”, as previously defined in [11]. This class covers job duties or tasks and is critical to matching job-seekers to jobs on the basis of what activities they are disposed to perform well or are credentialed to do. Another important set of terms are **Occupation Role**, defined as “A role borne by a human that, if realized, is realized when the bearer provides labor or services in exchange for compensation as specified by some deontic declaration”, and **Occupation Disposition**, “A disposition that, if realized, is realized when the bearer intends to, and does, exercise abilities and skills in pursuit of obtaining or maintaining an occupation role” [11].

Formally described ontologies like OccO have multiple purposes [16, 17]. The defined terminologies in ontologies can help to resolve confusion over meanings by precisely defining terms relevant to some domain. Also, they aid in the integration of disparate data by offering a core, common structure that these different data sources can be mapped to. By offering this common semantic framework, they can support federated querying across heterogeneous datasets. A single SPARQL query can make use of the semantics provided by the ontology, allowing it to be translated into source-specific queries for each of the distinct datasets [18]. This works by mapping each of the heterogeneous data source schemas to a common ontology, and using the axioms of the ontology, a SPARQL query made to the ontology can be rewritten as, say, multiple SQL queries tailored to each of the data sources. Given the terminological uncertainty and data interoperability problems in the occupation domain, an ontology is useful here for all of the above reasons.

This paper improves upon OccO by modeling terms related to occupational dispositions, including **competence**, **skill**, **ability**, and **capability**. These terms are critical for collecting data about what activities potential occupation-holders can successfully perform, which is crucial for making informed hiring decisions. We offer a precisely defined terminology which can provide guidance on how these terms relate to each other. We also discuss how OccO can aid in data integration despite widespread disagreement over the use of these terms. OccO does this by serving as a common framework which data sources using differing terminologies can be uniquely mapped to.

2. Definitions of high-level terms related to occupational dispositions

Because OccO is built as an extension of Basic Formal Ontology, every class in OccO fits within BFO's class hierarchy. BFO's primary division is between 'occurents' and 'continuants' [15]. Occurents are extended over time and have temporal parts, such as the process of walking or the temporal region during which you walk from point a to point b. 'Process' and 'temporal region' are thus both subclasses of occurrent. Occurents can be thought of as things that happen or take place in time, whereas continuants exist in time fully present whenever they exist. At any given moment in which you are walking, the walking process does not exist in full as it is spread across time. By contrast, you did not merely partially exist when you were 1 year old, this was you in your entirety, which makes you a continuant rather than an occurrent. Under continuants one finds 'independent continuants', which do not depend for their existence on anything else. Independent continuants include 'material entities', such as people, houses, planets, etc. These independent continuants are bearers of dependent entities, either 'generically dependent continuants' or 'specifically dependent continuants'. These differ according to whether they can only exist in some specific bearer or can exist across multiple copies of the same bearer. A novel's story would be an example of a generically dependent continuant, since the same story depends for its existence on many copies of the same book. Specifically dependent continuants can be either 'qualities' or 'realizable entities'. Realizable entities require some process to realize them, while qualities are present fully without need to be realized. The hardness of an object would be an example of a quality. An important division in realizable entities is between 'disposition' and 'role'. If a realizable entity is a role, it is present because of some context that is external to the bearer of the role. One's citizenship to a country is an example of a role; whether you are a citizen relies on legal facts independent of the internal, physical make-up of the citizen. By contrast, fragility is a classic example of a disposition. For a vase to no longer be fragile, its internal, physical composition would have to be altered such that it is no longer inclined to shatter if struck. Importantly, realizable entities do not have to be realized in order to exist. A fragile vase is fragile even if it is not actively shattering.

The preceding resources from BFO provide a foundation for OccO, and in doing so provide a foundation for our extension of OccO. In **Table 1**, we define various terms in OccO related to occupational competence.

Table 1
Definitions of **competence** and related terms in OccO

Label	Definition
capability ¹²	Disposition in whose realization some organism or group of organisms has or had an interest.
occupational ³ capability	Capability that must be realized ⁴ to successfully perform some occupation activity which realizes an occupation role or occupation disposition possessed by the person the occupational capability inheres in. Capabilities count as occupational capabilities if they are important to performing work relevant to their occupation.
skill	Capability that is the result of some specialized experience or training.
occupational skill	Skill that must be realized to successfully perform some occupation activity which realizes an occupation role or occupation disposition possessed by the person the occupational skill inheres in.
natural capability	Capability that is either innate or arises as part of an organism's healthy biological development.

Table 1Definitions of **competence** and related terms in OccO (continued)

Label	Definition
natural occupational capability	Natural capability that must be realized to successfully perform some occupation activity which realizes an occupation role or occupation disposition possessed by the person the natural occupational capability inheres in.
ability	Capability that persists for a prolonged period of time.
occupational ability	Ability that must be realized to successfully perform some occupation activity which realizes an occupation role or occupation disposition possessed by the person the occupational ability inheres in.
knowledge	Belief ⁵ where the believed proposition is true and the believer has a strong epistemic basis for believing it.
occupational knowledge	Knowledge the possession of which is necessary for the successful performance of some occupation activity which realizes an occupation role or occupation disposition possessed by the person the occupational knowledge inheres in.
competence	Capability ⁶ for employing some set of dispositions to succeed in some domain, such as in an occupation.
occupational competence	Competence for employing dispositions to succeed in an occupation ⁷ .
competence assessment	Act of Appraisal ⁸ which evaluates the presence of some competence in an individual.

A notable term we are making use of in OccO is **capability**. ‘Capability’ is not presently a class in BFO. However, it has been defined by [19] for potential inclusion into BFO. They define capability as a disposition in whose realization some organism or group of organisms has or had an interest. On their account, one has an interest in something if it contributes to their survival, reproduction, or goals. Tools used for matching people to jobs they are adept in are centrally concerned with what those individuals are capable of doing. A capability is a feature of a person that inheres in them even if they are not actively performing the relevant action. For example, someone can be capable of playing a piano without actively playing a piano. For this reason, capabilities are treated as BFO realizable entities. They are also internally grounded, rather than externally grounded, so they are more specifically BFO dispositions rather than roles.⁹ If one were to gain or lose a capability, there would need to be some material change to that individual.

¹Defined in [19]. The Mental Functioning Ontology [20] also has a definition for ‘Capability’: “A bodily disposition whose realization ordinarily brings benefits to an organism or group of organisms, where ”ordinarily” means within a typical range or context,” though their definition does not align precisely with the one we use.

²‘Aptitudes’ are often understood as acquired or natural abilities for behavior one has an interest in [21], including skills and abilities, and therefore can be understood as synonymous with capabilities.

³‘Occupational’ capabilities imply the existence of non-occupational capabilities. Although these surely exist, we do not cover them in much detail, due to OccO’s scope being restricted to occupation-related entities. We briefly discuss non-occupational capabilities in Section 3.

⁴Terms such as ‘realized’ and ‘inheres’ are derived from BFO.

⁵‘Belief’ is pulled from the Mental Functioning Ontology.

⁶Capabilities may or may not utilize other dispositions and are not necessarily for success in a clearly defined domain.

⁷The realization of occupational competences is necessary to fulfill occupation roles.

⁸‘Act of Appraisal’ is pulled from the Common Core Ontologies.

⁹One might reasonably object that, because realizable entities only count as capabilities if some organism has an interest in its realization, they are actually externally grounded like roles rather than internally grounded. However, to distinguish between roles and dispositions in BFO, we should analyze whether the realizable entity would cease to exist only if there is some underlying physical change to the bearer. Suppose that some organism has an interest in the realization of a disposition x. Due to this interest, x is counted as a capability. Now supposing this interest were lost without any physical change to the

Many of the terms we are here defining are types of capabilities, including competence, ability, and skill, as displayed in **Figure 1**.

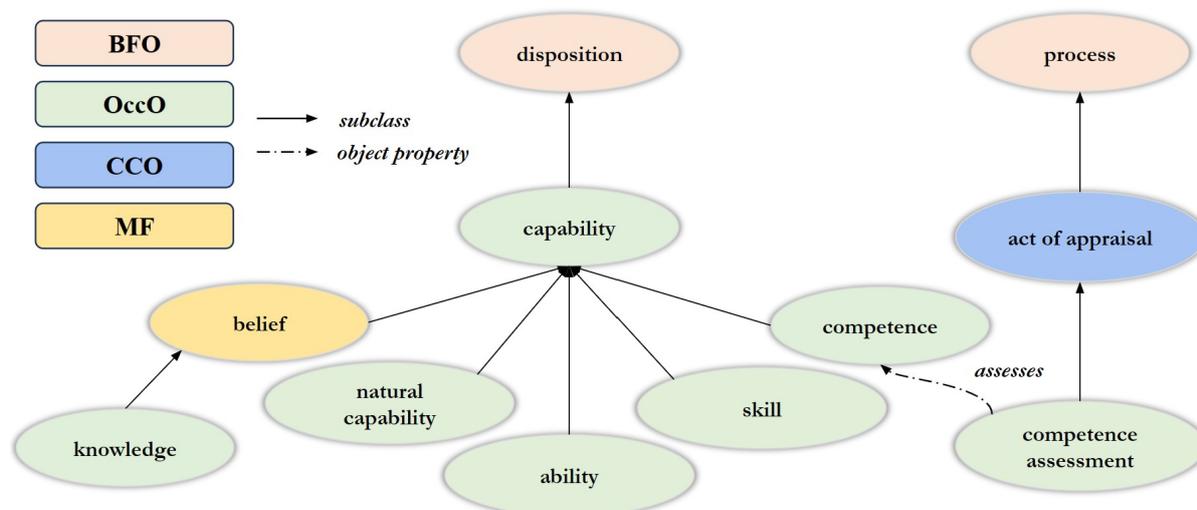


Figure 1: OccO classes covered in this paper, along with their parent classes. The abbreviations are as follows: Basic Formal Ontology (BFO), Occupation Ontology (OccO), Common Core Ontologies (CCO), and Mental Functioning Ontology (MF).¹⁰

3. Ontological modeling of capabilities: skill and ability

Terms like ‘skill’ and ‘ability’ are frequently used interchangeably, but some groups collecting data about occupational capabilities mark a distinction between them. Still, the precise distinctions they intend for these terms is often unclear. An example of a source that treats these as largely overlapping is O*NET. They allow users to browse by ability, describing them as “enduring attributes of the individual that influence performance” [5]. Examples of O*NET abilities include ‘selective attention’, ‘deductive reasoning’, ‘stamina’, ‘finger dexterity’, and ‘hearing sensitivity’. O*NET also includes several sorts of skills, including ‘basic skills’ [22], ‘cross-functional skills’ [23], and ‘soft skills’ [24]. Skills in O*NET are frequently described as being ‘developed’. For example, O*NET basic skills are “developed capacities that facilitate learning or the more rapid acquisition of knowledge” [22], and cross-functional skills are “developed capacities that facilitate performance of activities that occur across jobs” [23].

Based on the definitions of skill and ability from O*NET, it appears that skills and abilities are not mutually exclusive classes. Indeed, many terms in O*NET listed as skills either overlap significantly with O*NET abilities or appear to be identical to them. For example, ‘Reading Comprehension’ is a type of Basic Skill, defined as “Understanding written sentences and paragraphs in work-related documents” [22], whereas ‘Written Comprehension’ is an Ability defined as “The ability to read and understand information and ideas presented in writing” [5]. As another example, ‘Mathematics’ is also an example of a Basic Skill, defined as “Using mathematics to solve problems” [22], and ‘Mathematical Reasoning’ is a type of Ability, defined as “The ability to choose the right mathematical methods or formulas to solve a problem” [5].

Basic Formal Ontology (BFO) can be helpful for ordering these groups. Minimally, these terms are all referring to realizable abilities. Someone can have an ability for mathematical reasoning even when

bearer of x, even if it was therefore granted that x is no longer a capability, it would not follow that x thereby ceases to exist. The underlying realizable entity would still be present, even if it is no longer characterized as a capability. Additionally, Beverley et al. [19] argue that capabilities maintain their status as capabilities even when any interest in them is lost.

¹⁰Object properties in Figure 1 (and in all subsequent figures) express that any instance of the domain class bears this relation to some instance of the range class.

they are not actively choosing the right mathematical method or formula to solve a problem, and they can have a skill for reading comprehension, even when they are not actively understanding written sentences and paragraphs in work-related documents. Further, choosing those methods or formulas would realize the ability for mathematical reasoning, and understanding those written documents would realize the skill for reading comprehension.

We can also further classify these as dispositions rather than roles. For you to lose any of these skills or abilities, something internal to you would need to change. This is unlike, for instance, having an employee role, which depends on the external fact of whether you are employed by some organization. And lastly, we can place all of these as types of capability. All of the skill and ability terms in O*NET refer to dispositions the realization of which someone has an interest in. Workers have an interest in these skills and abilities in that they make themselves marketable, and businesses have an interest in that they add value to themselves.

As the reading and mathematics examples illustrate, there is not a clear division between O*NET skills and abilities, but they can both be confidently represented as various sorts of capability. Given the domain O*NET is concerned with, instances of ability and skill they discuss are likely to be what we refer to as **Occupational Capabilities**, a defined class of capabilities that must be realized to successfully perform some occupation activity which realizes an occupation role or occupation disposition possessed by the person the occupational capability inheres in. We include many other classes for capabilities that are particularly related to occupations, including **Occupational Skill**, **Occupational Ability**, and **Occupational Competence**¹¹. Because ‘Occupational Capability’ is a defined class, we can infer these classes as being subclasses of occupational capability without them being explicitly asserted as subclasses of it, as illustrated by **Figure 2**.

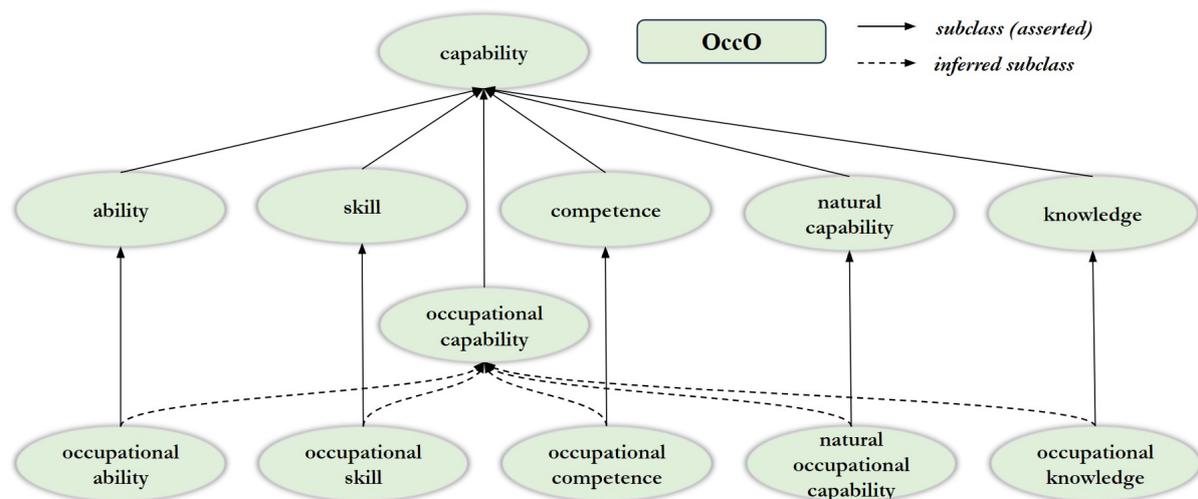


Figure 2: Occupation-specific disposition classes in OccO. Occupational skill, ability, knowledge, natural capability, and competence are asserted as subclasses of capability but can be inferred as subclasses of occupational capability.

Our definition of occupational capability is designed to make it contextual whether a particular capability is an occupational capability. For example, an instance of driving capability could be an occupational capability, say if this capability inheres in someone who works as a truck driver and consequently needs this capability for their job. But if this individual were to retire, their driving capability would thereby become detached from any occupation role or occupation disposition and consequently would cease to be an occupational capability.

In representing capabilities, we can move from more general to more specific. For example, many capabilities related to speech, writing, and gestures would count as communication capabilities. Many of

¹¹We give our account of competence in section 5.

these are natural language communication capabilities, such as speaking or writing English or Spanish. But communication capabilities can also include more specialized languages, such as programming languages, from general purpose languages like Python to more niche languages like SQL.

Many accounts of skill treat these as being definitionally the result of some experience, training, or study. For example, the job search company Indeed describes skills as being “developed through life and work experiences and they can also be learned through study” [25]. One definition of skill from Merriam Webster presents it as “learned power of doing something competently : a developed aptitude or ability” [26], and a definition from Britannica Dictionary makes it “the ability to do something that comes from training, experience, or practice” [27]. The Canadian Occupational Classification defines skills as “developed capabilities that an individual must have to be effective in a job, role, function, task, or duty” [28]. O*NET reflects this by referring to skills as being ‘developed’ [22, 23, 24]. Further, in supplementary documentation, O*NET defines skills as “proficiencies that are developed through training or experience” [6]. To represent this, we make **Skills** learned capabilities, which can be the result of some specialized training, including study or some on-the-job experience. This makes skill an expansive class of capabilities, excluding capabilities that are innate rather than developed. However, not every stakeholder in this domain maintains that skills are definitionally learned. We therefore offer an alternative, more neutral alternative label for this class: ‘Learned Capability’.

We adopt O*NET’s conception of abilities as “enduring” attributes that influence performance [5]. In OccO, **Ability** is any capability that persists for a prolonged period of time and influences performance. We make this decision for a number of reasons. One is due to the widespread usage of O*NET for representing job-related data in the US. Additionally, we maintain the distinction of enduring vs. transient capabilities is useful. Consider the difference between someone who crams the night before an exam compared with someone who is well-read in the subject. The former might be capable of recalling the relevant information for the exam, but this recall capability is not likely to be long-lived. Someone may get quick training from an expert to do some job for a short period of time but may forget how to consistently do it. This can be called a skill but not an ability. Hiring organizations have a particular interest in persistent capabilities which are not so easily lost. A capability that is short-lived may be a skill on account of it being trained, but this does not make it an ability, which may be more valuable to these groups.

Like ‘Skill’, stakeholders are not universally in agreement on how to define ability. Some definitions will treat abilities as ‘generally’ innate or even mandate them to be innate. For instance, Indeed explained that “While most abilities are inherent, it is possible to develop them through training” [29]. Elsewhere, Indeed defines abilities as “talents that are naturally occurring”, which are contrasted from learned skills [30].

In order to respect the terminological uncertainty surrounding ability, we offer an alternative label for the ability class: ‘Enduring Capability’. Crucially, Skill and Ability are not disjoint classes on our account. A learned capability can at the same time be enduring, though this is not always the case, as in a short-lived capability to perform well on an exam that results from cramming the night before. Skills also tend to be more work-related than abilities, since capabilities that are the result of specialized training are likely to be developed for success in some occupation, whereas Abilities can be more general and widely applicable.

We additionally include a class we refer to as **Natural Capability**, these being capabilities that are either innate or arise as part of an organism’s healthy biological development. Organizations which distinguish skills and abilities on the basis of trained vs. skill can map their skill classes to ‘Natural Capability’. Notably, there are very few capabilities which could be characterized as truly ‘innate’, either because they are not literally present at birth or because they are cultivated with some level of training or practice, as in the case of speech or walking capabilities. We therefore allow natural capabilities to also include those that naturally occur as part of an organism’s healthy development. This excludes capabilities that are the result of some specialized training, such as a coding capability, but includes ones attributable to a canonical member of a species, such as speech in humans.

Like skill, natural capabilities can overlap with abilities. In fact, capabilities that arise from birth are likely to be abilities, since they have endured for so long. This strong overlap likely contributes to the

confusion over these two classes.

It should also be noted that ‘ability’ is used interchangeably with ‘power’ or ‘skill’ and treated as a simple capability to do something [31, 32]. This usage of ‘ability’ maps straightforwardly to our ‘capability’ class.

4. Ontological modeling of knowledge

Another trait that is relevant to success or failure at an occupational role is knowledge. In order to be capable at a job, there is some set of information that must be known. A common distinction in the literature about knowledge is between propositional knowledge (‘knowledge that’), procedural knowledge (‘knowledge how’), and acquaintance knowledge (‘knowledge who’) [33, 34]. Propositional knowledge involves the knower comprehending some fact or set of facts, such as having knowledge about biology, procedural knowledge involves being able to perform some action, such as being able to ride a bike, and acquaintance knowledge involves being familiar with an individual, such as being acquainted with your neighbor. Procedural knowledge is well-handled in OccO with ‘Capability’. Propositional knowledge, on the other hand, needs further treatment since it is also important for occupation holders to perform occupational activities, and credentials are generally understood to be signifiers of propositional knowledge.

Defining knowledge precisely is a notoriously difficult philosophical task which is beyond the scope of an occupation ontology. For example, there is no firm consensus on whether the JTB (Justified True Belief) account of knowledge is critically flawed and needs to be abandoned, despite Gettier’s criticisms [35], and litigating this issue is too expansive of a task for our purposes. Because JTB and its variations remain the predominant accounts of knowledge, and because they succeed in the overwhelming majority of standard cases which are likely to be relevant to our domain, we are comfortable adhering to JTB for OccO.¹² For our purposes, we focus on where knowledge should be placed in a BFO-hierarchy.

Knowledge should be understood as a realizable entity. Some piece of information can be known even when it is not present to mind, and it is realized through recalling and assenting to this information. It is further a disposition, in that whether some information is known depends on facts about the knower, not about the context the knower finds themselves in. In order to cease knowing some information, it would have to be forgotten or rejected by the knower.

In keeping with the traditional JTB definition of knowledge, and without venturing too far into murky philosophical waters, we define **knowledge** as “Belief where the believed proposition is true and the believer has a strong epistemic basis for believing it.” We do not take a stance on whether this epistemic basis must be having evidence for the belief or the belief being formed in the right manner. Importantly, possessing knowledge implies the presence of at least one capability, this being a capability to recall the information that is known.

The Mental Functioning Ontology has its own class for Belief. They treat belief as a type of mental disposition, specifically “A mental disposition to represent a proposition to be true” [20]. This coheres well with our treatment of knowledge as a sort of disposition, so we adopt it as a parent class for knowledge. We further place both belief and knowledge as subclasses of capability, due to this class being so widely applicable.

Instead of referring to knowledge as a disposition inhering in an individual, users may instead intend to refer to some information that is known. This usage coheres with usage of the term ‘knowledge’ to mean some set of facts. This can easily be accomplished with an object property, ‘knows’, between a person and some information, this information being a generically dependent continuant.

¹²There is also significant discussion regarding whether the justification component of knowledge requires having evidence or a belief that is formed in an epistemically reliable manner [36]. Regarding this dispute, we do not decide what counts as a ‘strong epistemic basis’. This might come in the form of justifying evidence for the belief, or alternatively this might involve the belief having been formed in the epistemically correct way.

5. Ontological modeling of competence

One more term that is relevant to occupational capabilities is ‘Competence’. Organizations that collect data about what potential job holders can do frequently refer to competences. There is substantial confusion over the meaning of occupation-related terms, including about competence. Some groups make ‘competence’ a grab-bag for any disposition that might be relevant to succeeding as an occupation holder. For instance, the Credential Engine defines Competence as “Measurable or observable knowledge, skill, or ability necessary to successful performance of a person” [7]. Others use the term ‘competence’ interchangeably with ‘skill’. As an example, in the OECD Survey of Adult Skills, the authors explain that “no attempt is made to differentiate competency and skill,” despite others distinguishing between them [37]. However, other organizations have found surprising agreement in defining competence in a more constrained and distinct manner.

The Alabama Talent Triad defines competence as “the capability to apply or use a set of knowledge, skills, and intellectual behaviors to thrive in a defined field or career setting” [8]. This definition treats competence as a ‘second-order’ sort of disposition; it is a capability to employ other dispositions (knowledge, skills, etc.) to succeed in some domain. Similarly, ESCO defines competence as “the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development” [9]. Here again, competence is defined as a second-order disposition to use other dispositions to succeed.

We agree with classifying competence as a capability. A competence is a characteristic that inheres in an individual that is present even when unrealized and is internally rather than externally grounded, so it is properly understood as a type of disposition. It is also a disposition which an individual has an interest in its realization. We therefore model competence in OccO as it is defined by Alabama and ESCO.

In-line with the above treatment of competence, we define **Competence** as a “capability for employing some set of dispositions to succeed in some domain, such as in an occupation.” An **Occupational Competence** is then a “competence for employing dispositions to succeed in an occupation”. Not all competences are oriented toward occupational domains. For example, one might have a competence for employing various dispositions to participate in a hobby or game. A particular capability might be relevant to occupations, as well as to hobbies, games, and other domains, but meaningful distinctions between these categories can nonetheless be recognized.

Competences are distinguishable from other capabilities. Where most capabilities enable an individual to perform some task, such as a foreign language skill, competences enable success in a relevant domain like a career. A user of OccO might usefully refer to a customer service competence, which implies the presence of a suite of different dispositions, including possessing a communication skill, a conflict resolution skill, and a friendly attitude. Someone might more specifically have a retail customer service competence, which would further imply the presence of knowledge relevant to customer service in a retail context. **Figure 3** illustrates how competences depend¹³ for their existence on the presence of other related dispositions.

Hiring groups have a strong interest in checking whether a worker is competent at performing occupational activities for a role that they need to fill. This is done through hiring interviews and performance evaluations. These activities assess one’s competence. A **Competence Assessment** is an “Act of Appraisal which evaluates the presence of some competence in an individual”. ‘Act of Appraisal’ is a term we draw from the Common Core Ontologies (CCO), a suite of mid-level ontologies extending from BFO [39]. It is “An Act of Measuring that involves evaluating, assessing, estimating, or judging the nature, value, importance, condition, or quality of something or someone”.

Another feature of competences is that they can serve as qualifications for performing occupational

¹³Presently, BFO lacks a *depends on* relation. Recently, Rabenberg et al. have described dependence grounding relations for realizable entities, including ‘internally’ and ‘externally’ grounded [38]. However, these are relations between realizable entities and qualities, whereas the dependence relation we intend is between two realizable entities. In future work, it needs to be decided what the precise nature of this dependence relation is, apart from merely expressing that one entity requires another entity to be present.

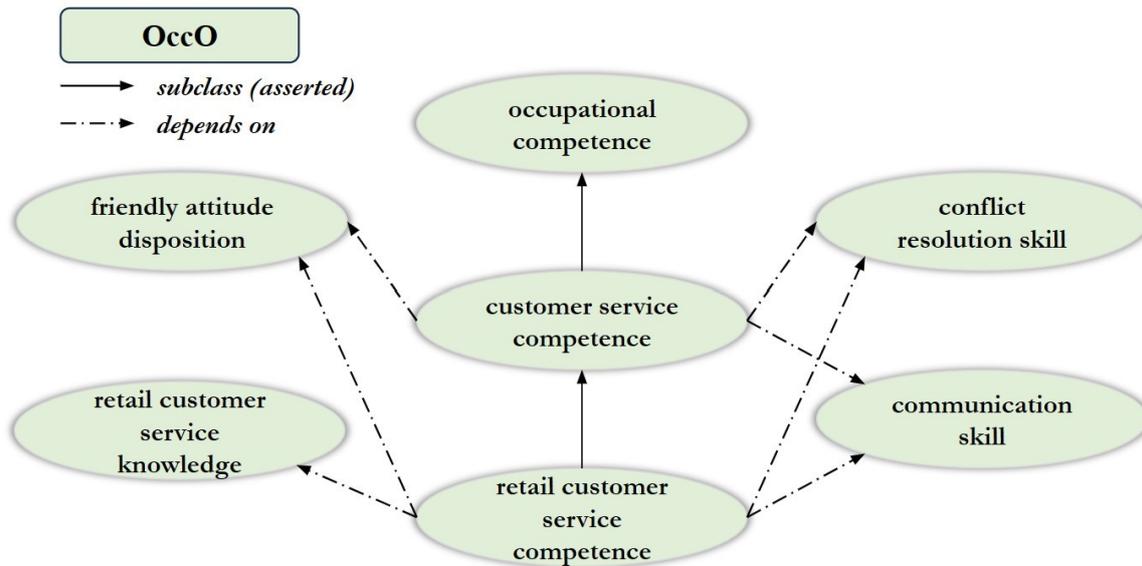


Figure 3: Customer service competences depend for their existence on many other dispositions being present in an individual. The figure does not display every disposition a (retail) customer service competence may depend on.

activities and holding certain occupational roles. Credentials operate as evidence of various characteristics of an individual, such as their having completed some training program or, more relevantly, their being the bearers of skills, abilities, competences, and other dispositions that make them qualified to do some work.

For those who conceive of competences, not as capabilities to utilize various dispositions, but instead as the dispositions themselves which are relevant to some domain, this would map onto defined classes of capabilities.¹⁴ In particular, if occupational competences are conceived of as any capabilities which are necessary to succeed in some occupation, this meaning would directly map onto OccO ‘Occupational Capability’. This offers an avenue for groups such as the Credential Engine to link up to OccO even if they do not adopt our definition of ‘Competence’.

6. Discussion

OccO is informed by the expertise of occupation domain experts, but there is significant disagreement among experts over the appropriate use of key terminology in this domain. One benefit of OccO is that it offers a coherent taxonomy that can help bring consistency amongst occupation researchers. However, even if the precise terminology of OccO is not adopted or agreed upon by some stakeholder in the occupation domain, OccO can still aid them in integrating data. Users of OccO can map their meanings into the ontology, allowing for translation of data, without being required to reinvent their taxonomies. A user might disagree, for instance, with making skills definitionally the result of some specialized training. When they use this term, they might instead have a meaning that corresponds with how we define capability itself. By mapping diverse taxonomies to a common data model, data can be integrated even where there is significant dispute over the meaning of terms.

Users of OccO may have their own terms which encompass multiple other dispositions. For example, ‘knowledge, skills, and abilities’ (KSAs) is often used as a term of its own [40]. Defined classes are classes with a set of necessary and sufficient conditions, which allows instances to be inferred on the basis of equivalence axioms included to the ontology [41]. These can be used to account for such terms.

¹⁴Users are also welcome to use alternative labels for any classes in OccO. We offer alternative labels where intuitive ones are available, such as ‘learned capability’ being a replacement for skill. A potential alternative label for competence as we have defined it might be ‘proficiency’.

A defined class for KSA, for instance, would be any capability that is an instance of knowledge, skill, or ability. Similarly, rather than second-order capabilities, competences are frequently conceived of as various dispositions including KSAs. Here again, a defined class would cover the use of ‘competence’ in this manner.

OccO’s applicability despite widespread terminological dispute is highlighted in the use-case of federated queries. Once multiple heterogeneous data sources are mapped to OccO, a single SPARQL query can generate SQL queries tailored to the different taxonomies of each data source. In future work, we intend to expand on this use of OccO by mapping the ontology to different data sources and construct tools that will aid users in performing these federated queries. We intend to explicitly express how the hierarchy of OccO relates to the hierarchies expressed in alternative resources, making querying between them substantially easier.

It is crucial for the Occupation Ontology to be able to represent what potential occupation holders are able to do and how they are disposed to behave. Using BFO as our upper-level structure, OccO can provide a clean framework for representing skills, abilities, capabilities, competences, knowledge, and other dispositions related to the occupation domain. The use of these terms by stakeholder organizations can be murky and inconsistent, but OccO can serve as a precisely defined common framework that differing occupation taxonomies can link up to, allowing easy translation of data from different sources.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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