

# Logic and Constructivism: A Model of Terminological Knowledge

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## Abstract

This original research hypothesises that the most fundamental building blocks of logical descriptions of cognitive, or knowledge, agents' descriptions are expressible based on their conceptions (of the world). This article conceptually and logically analyses agents' conceptions in order to offer a constructivist-based logical model for terminological knowledge. The most significant characteristic of [terminological] knowing is that there are strong interrelationships between terminological knowledge and the individualistic constructed, and to-be-constructed, models of knowledge. Correspondingly, I conceptually and logically analyse conception expressions based on terminological knowledge, and I show how terminological knowledge may reasonably be assumed to be constructed based on the agents' conceptions of the world. The focus of my model is on terminological knowledge structures, which may find applications in such diverse fields as the Semantic Web and educational/learning systems.

**Key words:** Terminological knowledge; Constructivist Epistemology; Logic; Concept; Conception; Conception's Effect

## 1 Introduction

In this article, I shall reflect on, and interpret, the phenomenon of *knowledge* from the perspective of *constructivist epistemology*<sup>1</sup> (see Piaget, 1967; Glasersfeld, 1984;

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<sup>1</sup>The term "epistemology" is derived from *episteme* (Ancient Greek: *epistēmē*). It is worth mentioning that Michel Foucault (1966) uses the term "epistēmē" to designate the *a priori* knowledge that grounds truth and discourses, thus representing the condition of their possibility within a particular epoch. In the framework of constructivism, there might be some similarities between my notion of epistemology and Foucault's *epistemes*.

Husén & Postlethwaite, 1989; Glasersfeld, 1989; Sjøberg, 2010). This expression was first used by Jean Piaget in 1967 in a direct reference to the mathematician L. E. J. Brouwer and his constructivism in mathematics.<sup>2</sup> In a very broad sense, constructivist epistemology—based on what can be called *the developmental theory of knowledge*—deals with the question of whether, and under which conditions, an individual may construct their own knowledge structures and produce their understanding of the world. One could say that such an epistemology is concerned with the *howness* of meaning construction based on the cognitive, or knowledge, agents' (henceforth simply "agents") experiences of, as well as on their conceptual/mental backgrounds about, the world. Correspondingly, it is assumed that there is a strong dependency between the constructed knowledge and the agent's conceptual models of knowing (in the mind/a knowledge base).

This research presupposes that knowing the world is not just seeing (and finding out about) something (some phenomenon); it is actually constructing it. As it will be made clearer in the next Section, this conception of knowing is significantly in line with Jerome Bruner's cognitive learning theory. I shall assume that knowing is a process of constructing knowledge [structures] in the mind, as well as in any other knowledge base. Consequently, knowledge can be understood as a compendium of (and, in fact, a construction based on) conceptual entities, conceptual relationships, and rules that have proven to be useful in expressing an agent's experiential world in the form of conceptions. In my view, and in the framework of constructivist epistemology, agents conceptually-logically-terminologically offer their conceptual expressions and, correspondingly, become concerned with the specification(s) of their conceptualisation through inferential and learning processes.

This paper informally conceptualises agents' conceptions of the world.<sup>3</sup> Accordingly, it theoretically analyses *terminological knowledge*. As the most significant contribution, it focuses on how terminological knowledge may reasonably be assumed to be constructed based on the agents' conceptions of the world.

## 2 Theoretical Background

Giambattista Vico coined the phrase "*verum est ipsum factum*" and explained that "to know something means to know what parts it is made of and how they have been put together" (Vico, 1710/2005; Glasersfeld, 1995). This means/entails that an agent can know [about] their personal built-up conceptual and other mental constructions and can reflect these knowings on their experiences of the world.

Jerome Bruner paid special attention to the significance of categorisation (classification) in knowledge acquisition, as well as to knowledge construction, processes. He believed that all cognitive activities of human beings involve categories. In Bruner's view, to perceive is to categorise, to conceptualise is to categorise, to learn is to form categories, and to make decisions is to categorise (see Bruner & Austin, 1956; Bruner, 1973; Bruner, 1986; Bruner, 1990; Bruner & Kalmar, 1998). Moreover, according

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<sup>2</sup>L. E. J. Brouwer was, so to say, a life-long constructivist. His constructivism was firstly elaborated on in Brouwer (1907), his doctoral dissertation at the University of Amsterdam. See, e.g., Posy (1974) for a discussion of the evolution of Brouwer's constructivism.

<sup>3</sup>For a more formal discussion, see Badie (2020; 2017b).

to Bruner, knowing includes information selection, information transformation, decision making, generating hypotheses, and constructing meaning from information and experiences (see Foerster, 1981; Glasersfeld, 1984). I shall summarise his views by saying that *categorisation* is the process of constructing knowledge (bases); it is dependent on representations, and it is by means thereof that human beings make sense of their world. Furthermore, incoming information is organised in terms of pre-existing classes, or humans create new ones; where humans cannot perceive things, they go beyond the information given and make inferences based on what they do really know. It is interesting to remark that the constructivist view does not rule out inferential relations between different categories.

In my view, and as I have argued for in Badie (2017c), knowing is an active and dynamic process of knowledge construction. In fact, agents produce their conceptions based upon their pre-conceptions of (as well as background knowledge about) the world. Conceptions of the world are in an important sense expressed in many forms in a universe of discourse. Conceptions are rooted in presuppositions (and pre-conceptions). They are also open to being revised and updated. This means that a conception (of the world) is corrigible and is capable of being annulled.

### 3 Concepts

Over the years, the term “concept” has been used differently by many authors (Kant, 1781/2007; Bartlett, 1932; Peacocke, 1992; Allwood, 1999; Hampton & Moss, 2003; Margolis & Laurence, 2007; Margolis & Laurence, 2010; Götzsche, 2013; Margolis & Laurence, 2015). For Götzsche (2013) and Badie (2017c), concepts offer a linkage between the mental representations of linguistic expressions and the other mental images (e.g., representations of the world, representations of inner experiences) that an agent has in the mind or in a knowledge base.

According to Allwood (1999), we can discern three fundamental and traditional positions that apply to what a concept is. (i) Concepts are abstract phenomena which exist outside the mind and are completely independent of space and time. This position, first advocated by Plato, is called *conceptual realism* and it is currently espoused by many mathematicians and logicians. According to conceptual realism, concepts are eternal and unchangeable phenomena. Subsequently, concepts are assumed to have a real existence. (ii) Concepts are mental phenomena that are construed by human beings. This position is usually called *conceptualism*. Conceptualism is currently the most common view among psychologists, linguists, and cognitive scientists. Conceptualism was first advocated by Aristotle and the medieval semanticist Abelard. (iii) Concepts do not really exist. The only things that exist are (a) linguistic expressions and (b) things (both real and ideal) in the world that linguistic expressions can represent. In this view, our direct experience of the world is often identified with the world itself. This third position is usually called *nominalism*. According to nominalism, concepts are reduced to a name, linguistic expression, and/or symbol. Currently, nominalistic views are found among linguists, philosophers, logicians and psychologists who are influenced by so-called *behaviourism*. Nominalism originally emerged in antiquity in opposition to Platonic conceptual realism.

## 4 *Conceptions*

In my view, concepts are mental phenomena/entities that are construed by agents in a particular state of awareness. More specifically, concepts are produced based on the agents' conceptualisation (of the world), as well as on their social linguistic interactions and communications, which all require some degree of awareness. Interpreted in this way, these psychological suppositions are in line with conceptualism. So, the way I see it, concepts are the primary/fundamental units of humans' [terminological] knowledge and are the basic "materials" of humans' constructed meanings. Concepts are non-physical entities that are classifiable and serialisable in minds. They can be identified with the contents in, e.g., linguistic expressions, formal expressions, and/or numerical expressions. It follows that humans can reflect on/represent [the classes of] conceptual entities in artificial agents' knowledge bases, in order to [metaphorically] train them and to implement them in diverse machine learning paradigms.

This paper attempts to analyse concepts logically, in order to deal with terminological knowledge. In more suitable words, this research draws on *nominal conceptualism* (as I have introduced in Badie, 2020). Summing up this position, agents who are in some way aware of expressing their own descriptions of the world based on their mental concepts deal with their linguistic expressions that are spoken, written, and represented based on, e.g., letters, numbers, symbols. In more proper words, humans need to become "concerned" with the production of their conceptions of the world. Therefore, in my theoretical model, *conceptions* are the consequences of *concepts*.

As mentioned above, concepts are the basic "materials" of meanings. It follows that *meanings* can be regarded as *conceptual structures* (of concepts, as well as of conceptions). From a dynamic-semantic perspective, meanings can be regarded as some functions from pre-conceptions into conceptions (and, in fact, from conceptions into conceptions' updated forms). Regarding meanings as *conception-update functions*, any meaning is a dynamic conceptual structure that becomes updated over time.

It is an underlying research hypothesis of this paper that the most fundamental building blocks of humans' descriptions of (as well as statements about, specifications of, explanations of, justifications for, questions about, answers about) the world are expressible based on their conceptions.

Let me offer an example for the concept 'book'. Suppose that Bob has a conception of the concept 'book'. Bob, based on his conception of 'book', defines the concept 'book' as a 'certain kind of a collection of written sheets'. This concept definition can be expressed in Bob's relevant descriptions, explanations, justifications, questions, and answers in various contexts. Relying on Bob's conception that 'Book is a certain kind of a collection of written sheets', there is a mental and conceptual assignment from the description 'certain kind of a collection of written sheets' to the conceptual entity 'book'. Considering the proposition 'Book is a certain kind of a collection of written sheets', two concurrent relationships (i.e. a (i) hyperonym-hyponym or SuperClass-SubClass relationship and a (ii) hyponym-hyperonym or SubClass-SuperClass relationship) between the concept 'book' and the description 'certain kind of a collection of written sheets' has been constructed. Consequently, all characteristics, features and properties of 'certain kind of a collection of written sheets' are transformed into 'book', and vice-versa. Accordingly, considering Bob's conception (that 'Book is a cer-

tain kind of a collection of written sheets’), the concept ‘book’ is logically-semantically transformed into the propositional-like conception ‘Book is a certain kind of a collection of written sheets’ and this can, in turn, be transformed into the entity ‘book’.

So, Bob has conceptualised that there is a logical-semantic equivalence between a conceptual entity and a proposition. Such a logical-semantic equivalence has produced a hypothesis for Bob’s inferential and learning processes. In addition, regarding this hypothesis, Bob—by means of ‘is a’—has constructed a logical-terminological relationship between the conceptual entity ‘book’ and the description ‘certain kind of a collection of written sheets’. Note that Bob’s hypothesis is posed based on his conceptions of ‘certain’, ‘kind’, ‘collection’, ‘written’ and ‘sheet’. Also, Bob’s conception of ‘book’ is involved in, and is logically-terminologically subsumed under, his conceptions of ‘certain’, ‘kind’, ‘collection’, ‘written’ and ‘sheet’. In this example, an agent’s conception of a concept has been expressed in terms of a few of his other pre-conceptions. One may notice that Bob is—based on his research, experiments, and interactions with other agents—always able to update his conception of ‘book’ and, in fact, to reuse his current conception as the pre-conception of his future conception(s).

For the logical assessment of conceptions, any conception (of a concept) and its interconnections with other conceptions can—by means of *predication*<sup>4</sup>—be represented by symbols (see Badie, 2016a; 2017a). For example, for the logical-terminological assessment of one’s conception of the concept ‘dog’, the mental entity ‘Dog’ and its logical-terminological interrelationships with any other conceptual entity is predicatable and representable.

## 5 Logical Analysis of *Conception Expression*

In order to assess an agent’s conceptions logically we may represent the conception-based terminological knowledge over the triple  $\langle \mathcal{C}, \mathcal{S}, \mathcal{E} \rangle$ , where  $\mathcal{C}$ ,  $\mathcal{S}$ , and  $\mathcal{E}$  stand for *concept*, *singular*, and *effect*, respectively (see my research in Badie, 2020). Let me be more specific:

- A *conception* (of some concept  $\mathcal{C}$ )<sup>5</sup> is correlated with a [distinct] conceptual entity.
- A *singular*  $\mathcal{S}$  (e.g., **brian**, **spaghetti**, **skype**) is an instance of a conception (of a concept  $\mathcal{C}$ ). It can be interpreted as follows: any singular is an example, as well as a single occurrence, of a conception. Moreover, a singular can be classified under (and labelled by) a specific conception. In fact, by their semantic interpretations, agents can transform any singular into a specific conception (of the world).
- An *effect*  $\mathcal{E}$  (of a conception of a concept  $\mathcal{C}$ ) expresses a relationship between a singular (that has been conceptualised to be the instance of  $\mathcal{C}$ ) and other singulars (that are also conceptualised to be the instances of either  $\mathcal{C}$  or any other concept). In addition, an effect (of a conception of  $\mathcal{C}$ ) has the ability to

<sup>4</sup>As I have argued for in Badie (2017a), the predication of a conception is concerned with the question: “What does it mean to state something about that conception?” Actually, any predication is meant to describe and express what there is for a produced conception.

<sup>5</sup>See elaboration above.

assign a property/attribute to a singular (that is, in fact, covered/identified by  $\mathcal{C}$ ).

Any singular can be related to itself by means of the effect of *valence* 0. Specifically, interpreted via predicate logic, singulars are equivalent to constant symbols and can be regarded as 0-ary functions (that are mapped into constant symbols from themselves).

Assertional conception-based descriptions like, e.g., ‘Brian is a philosopher.’, ‘Ravioli is a [kind of] food.’, and ‘Skype is a computer application.’ are expressed based on the effects of valence 1. One may suggest that any effect of valence 1 is (or can be) addressed by ‘is a’ in a description in order to express the concept of ‘being’. According to the description ‘Ravioli is a [kind of] food.’, the singular *ravioli* has been conceptualised and described based on the conception of ‘food’. From the perspective of predicate logic, one’s conception of a concept can be interpreted as being “equivalent” to a unary predicate.

Assertional effect-based descriptions like, e.g., ‘Brian is a friend of Maria.’, ‘Ravioli, spaghetti, and arancini are cooked here.’, and ‘Skype is developed by Microsoft.’ are expressed based on the effects of valences greater than 1. Regarding the description ‘Skype is developed by Microsoft.’, the singulars *skype* and *microsoft* (that are the instances of the conceptions of two concepts) are conceptualised and realised to be related to each other by means of the effect ‘is developed by’. In other words, the singular *skype* has—by means of the effect ‘is developed by’—effected the singular *microsoft*. Equivalently and symmetrically, the singular *microsoft* has—by means of the effect ‘is developed by’—been effected by the singular *skype*. Considering the description ‘Ravioli, spaghetti, and arancini are cooked here.’, the singulars *ravioli*, *spaghetti* and *arancini* are conceptualised and realised to be related to each other by means of the effect ‘are cooked’. Assessed from the viewpoint of predicate logic, effects are logically equivalent to  $n$ -ary predicates.

## 6 Logical Analysis of *Terminological Knowledge*

Suppose that  $\mathcal{C}_1$  and  $\mathcal{C}_2$  stand for two concepts. Let me focus on some agent  $x$ . Basically,  $x$ ’s conceptions of  $\mathcal{C}_1$  and of  $\mathcal{C}_2$  are comparable in two ways. In particular:

- There might be a difference between  $x$ ’s conception of  $\mathcal{C}_1$  and  $x$ ’s conception of  $\mathcal{C}_2$ . The interpretation is, then, that  $x$ ’s conception of  $\mathcal{C}_1$  is semantically independent of  $x$ ’s conception of  $\mathcal{C}_2$ . That is, there is no conceptual-logical and no terminological relationship between  $x$ ’s conceptions of  $\mathcal{C}_1$  and of  $\mathcal{C}_2$ . In fact, conceptualising and knowing (by  $x$ ) that there is no conceptual, logical and semantic interconnection between these two conceptions, does not construct any terminological knowledge about  $\mathcal{C}_1$  and  $\mathcal{C}_2$  in  $x$ ’s mind or knowledge base.
- There might be a relationship (or more relationships) between  $x$ ’s conception of  $\mathcal{C}_1$  and  $x$ ’s conception of  $\mathcal{C}_2$ . Therefore, we can interpret that  $x$ ’s conception of  $\mathcal{C}_1$  (or  $\mathcal{C}_2$ ) is semantically dependent on  $x$ ’s conception of  $\mathcal{C}_2$  (or  $\mathcal{C}_1$ ). More specifically, there is/are conceptual, logical as well as terminological, relationship(s) between  $x$ ’s conceptions of  $\mathcal{C}_1$  and of  $\mathcal{C}_2$ , respectively. Therefore,

conceptualising and knowing (by  $x$ ) that there is/are conceptual, logical and semantic interconnection(s) between  $x$ 's two conceptions, can certainly constitute a building block of terminological knowledge about  $\mathcal{C}_1$  and  $\mathcal{C}_2$  in  $x$ 's mind or knowledge base. Considering the fact that  $x$ 's conceptions of  $\mathcal{C}_1$  and of  $\mathcal{C}_2$  are relevant to (and dependent on) each other, we can conclude the following:

- A. There might be a relationship of *equivalence* between  $x$ 's conception of  $\mathcal{C}_1$  and  $x$ 's conception of  $\mathcal{C}_2$ . So one may interpret that  $x$ 's conception of  $\mathcal{C}_1$  is semantically equivalent to  $x$ 's conception of  $\mathcal{C}_2$ . In fact, there is a clear conceptual, logical, and terminological relationship between  $x$ 's conceptions of  $\mathcal{C}_1$  and of  $\mathcal{C}_2$ . Obviously, conceptualising and knowing (by  $x$ ) that there is a direct and strong conceptual, logical, and semantic equivalence between the two conceptions can certainly produce an instance of terminological knowledge about  $\mathcal{C}_1$  and  $\mathcal{C}_2$  in  $x$ 's mind or knowledge base.
- B. There might be a relationship of *subsumption* between  $x$ 's conception of  $\mathcal{C}_1$  and  $x$ 's conception of  $\mathcal{C}_2$ . More specifically,  $x$ 's conception of  $\mathcal{C}_1$  might be subsumed under  $x$ 's conception of  $\mathcal{C}_2$ . This means that  $x$ 's conception of  $\mathcal{C}_1$  is  $x$ 's sub-conception of  $\mathcal{C}_2$ . Therefore, there is a clear conceptual, logical, and terminological relationship between  $x$ 's conceptions of  $\mathcal{C}_1$  and of  $\mathcal{C}_2$ . Consequently, conceptualising and knowing (by  $x$ ) that there is a direct and strong conceptual, logical, and semantic subsumption interconnection between the two conceptions can certainly construct a terminological knowledge about  $\mathcal{C}_1$  and  $\mathcal{C}_2$  in  $x$ 's mind or knowledge base.

I shall now, and based on an agent's conceptions of the world, logically analyse a terminological knowledge model. According to the first item, we may conclude that there is no way to model terminological knowledge when two conceptions of an agent are irrelevant to (and independent of) each other. But obviously an agent's conceptions of the world are terminologically describable based on the second item above. Correspondingly, terminological knowledge can fundamentally be modelled in the following forms:

*Conception equivalence.* Conception equivalence means *conception of concept equivalence*. Suppose that the logical term  $\mathcal{C}_1 \equiv \mathcal{C}_2$  represents the description 'it is conceptualised that the conception of the concept  $\mathcal{C}_1$  is equivalent to the conception of the concept  $\mathcal{C}_2$ '. Accordingly, we can have the description 'it is conceptualised that the conception  $\mathcal{C}_1$  is equivalent to the conception  $\mathcal{C}_2$ '. Semantically, the agent may interpret that the conception  $\mathcal{C}_1$  is equal to the conception  $\mathcal{C}_2$ . For example, Mary conceptualises that the concepts 'husband' and 'male spouse' are equivalent (note that I am not dealing with the truth/falsity of Mary's conception, but only with the logical-terminological structure of her conception). In fact, regarding Mary's terminological knowledge, her conceptions of 'husband' and 'male spouse' are equivalent.

*Effect equivalence.* Regarding the effect equivalence  $\mathcal{E}_1 \equiv \mathcal{E}_2$ , the agent may conceptualise that the effect  $\mathcal{E}_1$  is equivalent to the effect  $\mathcal{E}_2$ . Semantically, they may interpret that  $\mathcal{E}_1$  is equal to  $\mathcal{E}_2$ . It is worth noticing that *effect equivalence* means *conception of relation (effect) equivalence*. For example, Ann may conceptualise

that ‘to observe something’ is equivalent to ‘to see something’. For instance, she may conceptualise that ‘Ann observes the sun’ is equivalent to ‘Ann sees the sun’. Based on Ann’s terminological knowledge, there is an effect[-based] equivalence between ‘Ann observes the sun’ and ‘Ann sees the sun’. However, effect equivalences are dependent on (and are expressed based on) conception equivalences. Correspondingly, the agent may conceive the following interpretation: ‘the conception of the effect of the conception of the concept ‘observation’ is equivalent to ‘the conception of the effect of the conception of the concept ‘sight’’. This is, in fact, expressible based on ‘the conception of ‘observation’ is equivalent to ‘the conception of ‘sight’’.

*Conception subsumption.* According to  $\mathcal{C}_1 \sqsubseteq \mathcal{C}_2$ , the agent may conceptualise that the conception  $\mathcal{C}_1$  (that is, in fact, the conception of the concept  $\mathcal{C}_1$ ) is subsumed under the conception  $\mathcal{C}_2$  (the conception of the concept  $\mathcal{C}_2$ ). Semantically, the agent may interpret that  $\mathcal{C}_1$  is the sub-conception of  $\mathcal{C}_2$ . For example, regarding John’s conception, ‘flowers are plants’. Consequently, considering John’s terminological knowledge, his conception of ‘flower’ is subsumed under his conception of ‘plant’.

*Effect subsumption.* Regarding the effect subsumption  $\mathcal{E}_1 \sqsubseteq \mathcal{E}_2$ , the agent may conceptualise that the effect  $\mathcal{E}_1$  is subsumed under the effect  $\mathcal{E}_2$ . Semantically, it is interpreted that  $\mathcal{E}_1$  is the sub-effect of  $\mathcal{E}_2$ . For example, James has conceptualised that ‘To learn is to memorise’. For instance, he may conceptualise that ‘James learns history’ is ‘James memorises history’. According to James’ terminological knowledge, ‘James learns history’ is subsumed under ‘James memorises history’. However, effect subsumptions are dependent on conception subsumptions. Actually, the agent may interpret that ‘the conception of the effect of the conception of the concept ‘learning’ is subsumed under ‘the conception of the effect of the conception of the concept ‘memorisation’’. This is, in fact, expressible based on the equivalence between the conceptions of the concepts ‘learning’ and ‘memorisation’.

Summing up the above, we have the following theoretical results with respect to terminological knowledge:

- Terminological knowledge is an individually oriented structural model of knowledge.
- Terminological knowledge is fundamentally modelled based on an agent’s conceptions of: (i) concept equivalences, (ii) relation (and property) equivalences, (iii) concept subsumptions, and (iv) relation (and property) subsumptions. Actually, by building their terminological knowledge, agents attempt to satisfy their conceptual-terminological principles based on their conceptions of (i), (ii), (iii) and (iv).
- Terminological knowledge is logically expressible over the triple  $\langle \mathcal{C}, \mathcal{S}, \mathcal{E} \rangle$ .
- The most fundamental terminological rule in a terminological knowledge model is that an agent’s conceptions are, in the forms of equalities and subsumptions, modelled hierarchically in order to create terminologies.



## 7 Detailed Analysis of *Conception Expression* based on Terminological Knowledge

Above, I have assumed that—based on their terminological knowledge—agents are able to express their conceptions of the world. In what follows, I shall categorise the most salient logical characteristics of *conception expression* based on an agent’s terminological knowledge.

**I: Dealing with semantic valuation of conceptions.** One may assume that any agent has a conception of the concepts ‘Truth’ and ‘Falsity’. Accordingly, by *semantic valuation*, agents become “concerned” with the truth and falsity of their available conceptions of the world. In other words, regarding their conceptions of Truth and Falsity, they evaluate their conception of any specific concept. This semantic valuation of conceptions is describable in the following ways:

1. A *truth conception* that conceptualises and interprets the truth, as well as the validity and the acceptability, of an available conception of a concept based on all possible interpretations of that concept (by the agent).
2. A *falsity conception* that conceptualises and interprets the falsity, as well as the invalidity and the unacceptability, of an available conception of a concept based on all possible interpretations of that concept (by the agent).

**II: Conception expression based on conception/effect construction.** A *conception construction* is the production, as well as the development of, new conceptions based on the agent’s available conceptions of the world. Conception constructions are usually produced in the following forms:

1. A *conception implication* that produces/entails a new conception from an agent’s available conception of the world. For example, the conception of ‘instructor’ can be constructed based on the conception of ‘teacher’. According to *conception implication*, a new conception (of an agent), like  $C_2$ , can be drawn (in the mind or in a knowledge base) from their own available conception, like  $C_1$ , although  $C_1$  is not (might not be) explicitly stated in their descriptions. Relying on conception implications, *effect implications* are analysable. For example, regarding an agent’s terminological knowledge, the conception of ‘to be coloured’ can be produced based on the conception of ‘to be green’.
2. A *conception opposition* that expresses the absence of an agent’s available conception of the world. An opposition (or negation) of a specific conception (of an agent) invalidates and annuls that conception. For example, regarding an agent’s terminological knowledge, the conception of ‘no person’ can be constructed based on the conception of ‘person’. By considering conception oppositions, *effect oppositions* are analysable. For

example, regarding an agent's terminological knowledge, the conception of 'not to read a book' can be produced based on the conception of 'to read a book'.

3. A *conception conjunction* that produces the intersection (as well as the coincidence and concurrence) of two, or more, available conceptions of the world. For example, considering an agent's terminological knowledge, the conception of 'big brown bear' can be constructed based on the conceptions of 'bear', 'brown' and 'big'. By considering conception conjunctions, *effect conjunctions* are analysable. For example, regarding an agent's terminological knowledge, the conception of 'to read a book and smile' can be produced based on the conceptions of 'to read a book' and 'to smile'.
4. A *conception disjunction* that separates two, or more, available conceptions of the world. In fact, conception disjunction deals with the incoherence and disconnections of two, or more, conceptions. For example, in consideration of an agent's terminological knowledge, the conception of 'brown or red' can be made for choosing the colour of a chair, based on the conceptions of 'brown' and 'red'. More specifically, from the assertional point of view, an agent's conception of 'brown or red chair' can be made based on the conceptions of 'brown chair' and 'red chair'. Taking into account conception disjunctions, *effect disjunctions* are analysable. For example, by considering an agent's terminological knowledge, the conception of 'to write or play' (for choosing one's favourite activity) is creatable based on the conceptions of 'to write' and 'to play'. More particularly, from the assertional point of view, an agent's conception of 'to write an article or play chess' is made based on the conceptions of 'to write an article' and 'to play chess'.
5. A *conception quantification* that quantificationally assesses and appraises the available conceptions of the world. For example, regarding an agent's terminological knowledge, the conceptions of 'some birds' and 'all birds' are creatable based on the conception of, a (specific) group of, 'birds'. Conception quantifications and *effect quantifications* are strongly tied together. In fact, the quantification of an agent's conception(s) is dependent on the quantification of their conceptions' properties. In more adequate words, the quantification of an agent's conception(s) is dependent on the quantification of their conceptions' effects (on their other conceptions). For example, an agent that has made their conception of 'some birds' or 'all birds', has, in fact, quantified the available conception of 'birds', as well as of 'their properties (e.g., their breeds, their colours, their sizes, their songs)'.
6. A *conception qualification* that qualificationally evaluates the available conceptions of the world. For example, taking into consideration an agent's terminological knowledge, the conception of 'beautiful girl' can be made. Note that conception qualification is related to *conception conditioning* (see below). Conception qualifications and *effect qualifications* are related to each other. This means that the qualification of an agent's conceptions is dependent on the qualification of their conceptions' properties and, in fact, on the qualification of their conceptions' effects (on their other concep-

tions). For example, the agent (who has made the conception of ‘beautiful girl’) has qualified their conception of ‘girl’ as well as of ‘girls’ properties’.

**III: Dealing with conception/effect classification.** By means of *conception classification*, agents categorise and collect their available conceptions of the world. For example, taking into consideration an agent’s terminological knowledge, the conceptions of ‘tree’ and ‘flower’ may be classified under the conception of ‘plant’. In other words, the conceptions of ‘tree’ and ‘flower’ are subsumed under the conception of ‘plant’. Semantically, the conceptions of ‘tree’ and ‘flower’ may be interpreted as sub-conceptions of ‘plant’. In addition, we can analyse *effect classifications* based on conception classifications. Suppose that an agent’s conception of ‘to understand’ (based on their terminological knowledge) is classified into the conception of ‘to learn’. Subsequently, ‘to understand’ is the sub-effect of ‘to learn’. More particularly, the conception of ‘to understand German’ is the sub-effect of, and is interpreted to be subsumed under, the conception of ‘to learn German’.

**IV: Dealing with conception characterisation.** By means of *conception characterisation* agents specify their available conceptions of the world. In other words, by conception characterisation an agent assigns [indicative] characteristics to their conceptions. For example, an agent may have a conception of ‘a [specific] breed of dogs’. In fact, by having a conception of ‘a [specific] breed of dogs’, the agent characterises the conception of ‘dog’. Note that the characterisation of a conception is highly dependent on the characterisation of that conception’s effects (*effect characterisation*). Correspondingly, an agent needs to deal with the specification of the properties (and the attributes) of a group of dogs (e.g., having brown colour, being big, being smart) in order to produce the conception of ‘a [specific] breed of dogs’. Consequently, the conception of ‘dog’, as well as of ‘the effects of being [a] dog’, can be characterised (by the agent).

**IV-i: Dealing with conception identification.** *Conception identification* is a product of conception characterisation. Agents, by means of conception identification, recognise (and, in fact, make identifiers for) their available conceptions of the world. It should be stressed that the identification of an agent’s conception is dependent on the identification of the properties of that conception, as well as of its effects on the agent’s other conceptions. An agent may—based on their characterisation of their conception of the concept ‘dog’—produce their specifying and identifying conception of ‘dog’. Equivalently, they may produce their conception of ‘being [a] dog’, as well as of ‘to be [a] dog’.

**V: Dealing with functionalised conceptions.** By means of *conception functionalisation* agents create functions (i.e. functional relations) based on their available conceptions of the world. For example, one can—based on the conception of ‘to have a mother’—produce the supportive functionalised conception that ‘any human being has one (and only one) mother’. Obviously, the functionalisation of an agent’s conception is supported by the functionalisation of the properties

of that conception, as well as by the functionalisation of that conception's effects on other conceptions of the agent.

- VI: **Dealing with conception states.** A *conception state* is a particular condition (as well as location and moment) at/in/on which an available conception of the world has been true. It shall be interpreted that an agent's conception(s) has/have been experienced to be true at/in/on [specific] conception states. An agent who has experienced a true proposition, say  $P$ , at/in/on a specific state of the world may decide to develop their available conception based on the experienced  $P$ . For example, Daniel can—based on his conception of '[many] exams in February'—say 'I have had many exams in February'. Accordingly, by mentioning 'February', he can make a specific state of his conception of 'exam'.
- VII: **Dealing with nominalised conceptions.** By means of *conception nominalisation* agents transform their available conceptions of the world into specific nouns (as well as labels). Suppose that Anna was born on the 25th of March in 1974. Therefore, she can—by transforming the proposition 'I was born on the 25th of March in 1974' into the noun 'birthday' (and, subsequently, into the noun 'birth')—produce her own nominalised conception of 'birth'. Note that 'the 25th of March in 1974' may conceptually and terminologically be regarded as a specific state of the concept 'birth' in Anna's mind. Therefore, it should be taken into account that there is a strong correlation between conception state and conception nominalisation.
- VIII: **Dealing with conception conditioning.** By means of *conception conditioning* agents adapt their available conceptions of the world to specific conditions (as well as provisos and requirements). For example, one can—by provisioning the conception of 'food'—make the [conditioned and provisional] conception of 'good food'. It is important to remark that conception conditioning and conception qualification (item II-6) are related to each other.
- IX: **Dealing with conception collation.** By means of *conception collation* an agent compares their available conceptions of the world with each other. For example, one can—based on their conceptions of the singulars 'ubuntu' and 'debian' (that are conceptualised as the instances of 'Operating System')—focus on their conception collation.
- X: **Dealing with conception enumeration.** By means of *conception enumeration* agents can assign numbers to their available conceptions of the world (in order to count them). For example, an agent can—based on their conception of 'blue'—enumerate and count 'blue flowers' in the garden.

## 8 Concluding Remarks

Above, I focused conceptually and logically on a detailed analysis of terminological knowledge in the framework of constructivist epistemology.

My research hypothesises that the most fundamental building blocks of logical descriptions of agents' linguistic and formal expressions are expressible based on their

conceptions (of the world). Accordingly, I have analysed conception expressions, in order to model terminological knowledge. Terminological knowledge is a structural model of knowledge that is fundamentally modelled based on an agent's conceptions of concept/relation equivalences and of concept/relation subsumptions. Assessing an agent's conceptions logically, we may represent terminological knowledge over the triple  $\langle \mathcal{C}, \mathcal{S}, \mathcal{E} \rangle$ . More specifically, in order to logically model a fundamental terminological description we utilise the agents' conceptions, as well as the interrelationships between singulars (by means of effects).

I have assumed that the central focus of constructivist epistemology is at the origin of any individual's constructed terminological knowledge. Thus, constructed terminological knowledge (by an agent) is individually oriented. In such a framework, the most significant characteristic of knowing is that there are strong interrelationships between terminological knowledge and the individually oriented constructed and to-be-constructed models of knowledge. Correspondingly, when analysing terminological knowledge based on a constructivist model of knowing, we are faced with the questions of: (i) how an agent can/may know, in order to produce their terminological knowledge, and (ii) how terminological knowledge may reasonably and logically be assumed to be constructed by an agent based on their conceptions of the world. Some important consequences can now be summarily discussed.

According to *constructivist terminological knowing*, agents construct their own conceptual versions based on their own conceptions of the world. Assessing this from the perspective of nominal conceptualism, agents' own conceptual versions can be expressed/represented by letters, numbers, symbols, etc. With regard to nominal conceptualism, the most fundamental building blocks of agents' descriptions of the world are expressible based on their conceptions.

As for constructivist terminological knowing, the semantic phenomenon of meaning is interpreted as a conceptual structure that becomes constructed based upon the agents' conceptions. More particularly, meanings are functions from agents' conceptions into their updated forms. Consequently, there are solid interrelationships between *construction* and *semantic interpretation*. In fact, agents [semantically] interpret the world (based on the [semantic] interpretations of their own conceptions) and subsequently understand the world (by conceptualising, interpreting, and making sense thereof, based on their own conceptions). Actually, the constructed meanings (by an agent) become reflected in their understanding of the world (see Badie, 2016b; 2018).

With respect to constructivist terminological knowing, there are robust correlations between *constructing* and *explaining*. Therefore, relying on their own conceptualisations of the world, agents provide supportive backgrounds for producing their own meaningful descriptions.

In the framework of constructivism, logical-terminological modelling of terminological knowing relies on the concepts of 'classification' and 'induction'. More specifically, in the framework of constructivist terminological knowing, the inferential and reasoning processes of concept learning (what I call *constructivist concept learning*, see Badie, 2017b; 2017c) are mainly structured based on the conceptual processes of classification and induction. In fact, I believe that agents specify their conceptualisation of their conceptions through their inferential and reasoning processes based on their terminological knowledge.

The offered model of terminological knowledge has important potential applications. An application thereof in technological contexts might be in conception-expression [machine] learning within terminological knowledge structures in semantic technologies (e.g., the Semantic Web). For instance, it can support inductive reasoning<sup>6</sup> based on the agents' conceptions within multi-agent systems (MAS; see, e.g., Wooldridge, 2009), computerised systems composed of multiple interacting artificial agents that are mutually related with the aim of making decisions and/or solving problems in cooperation among each other. In other words, a significant potential application might be in what I call *Conception-oriented interaction-based terminological knowledge building & inductive reasoning in semantic technologies*.

Further applications can be envisaged in educational and pedagogical contexts. This model of terminological knowledge can support the logical analysis of students' conceptions, in order to improve our comprehension of their conception-based learning and understanding of specific subjects. This analysis might contribute to a better understanding by teachers, as well as by educationalists and learning designers, of the learning processes of students. In particular, it can support the logical analysis of how a learner can update their conceptions and share their constructed meanings (of their conceptions) when learning a subject. For example, when learning Geometry, learners may be asked (by their teachers) to, e.g., name [their conceptions], identify [their conceptions], explain [their conceptions], analyse [their conceptions], relate and combine [their conceptions together], justify [based on their conceptions], create [new conceptions based on their previous conceptions], and hypothesise [based on their conceptions]. Accordingly, teachers can logically analyse various layers of the learners' conception-based learning and understanding.

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<sup>6</sup>Inductive reasoning extends deductive reasoning to less-than-certain inferences.

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