Language for Deep Learning: Cognitive Explorative Action Games for Teacher-Learner Interactions*

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This paper explores the design of what I call explorative action games for teacher-learner interactions. I argue that explorative actions games scaffold the learner’s re-representation of knowledge in ways that facilitate higher-level thinking and deep reasoning. With reference to Weigand’s (2010) Theory of Dialogic Action Games, I introduce the minimal form of the game, which consists of the explorative and the discovery speech act pair. Both speech acts are mutually related to each other. The explorative action game thereby revolves around knowledge re-representations in terms of Chi and Ohlsson’s (2005) types of changes with special emphasis on “greater complexity”, “higher level of abstraction”, and “shifted vantage point”. I illustrate explorative action games for these types and show how they are linked to deep learning and dialogic knowledge building.

Key words: explorative action games, re-representation of knowledge, teacher-learner interaction, dialogic knowledge building

1. Why cognitive explorative action games?

When people interact with each other, they leave traces of what they are doing. In communication, they produce utterances, for instance, which they use for certain things. Conversation Analysis, which was first introduced by Sacks, Schegloff & Jefferson (1974), is one branch of linguistics which investigates language on the level of the utterance. Sinclair & Coulthard (1992) adapted this methodology to Speech Act Theory for the analysis of classroom talk.

But dealing with teacher-learner interactions leads sooner or later to the
question: what is going on in people’s heads? We need to understand the
cognitive states that underlie what the interlocutors are doing on the visible
and audible level of the interaction (cf. Schalley & Khlentzos, 2007). In
a teacher-learner interaction, just like in any other type of interaction, the
interlocutors use language for certain purposes. More precisely, they use
language to carry out actions. These actions, on the other hand, are always
connected to cognitive states and processes. This connection is often hidden
in language use.

To give an example, let us take a look at conceptual metonymy. Here an
instance from Niemeier (2004, p.111):

The Rolls-Royce left the gas station without paying.

It is immediately understood that it is the driver of the Rolls-Royce who
has left without paying. The Rolls-Royce stands here merely as a place
holder. This intended interpretation is not expressed on the verbal level but
is inferred by the interlocutor.

Levinson’s (2000, p. 16) particularized conversational implicature (PCI)
works along similar lines:

A: What time is it?
B: Some of the guests are already leaving.
 PCI: It must be late.

In this short sequence, A infers the PCI against background information
(including social conventions about how long guests usually attend a social
event) which is not explicitly mentioned on the verbal level. Cognitive
processes like these naturally occur in language use all the time. Especially
in the teaching and learning context, where learning ultimately takes place
in the learner’s head, essential parts of the interaction happen on the non-
verbal level. We have to incorporate the cognitive level in the description of
the interaction if we want to understand what is actually going on.
2. Knowledge building via re-representation

The cognitive states of the interlocutors are an essential part of any interaction. They are part of the picture of what is going on when people talk to each other. Teaching and learning interactions are no exception here. In contrast, these interactions revolve around a vast network of cognitive processes including reasoning, inferring, and understanding, that ultimately combine to what I call knowledge building, i.e., in other words, learning.

Furthermore, the increasing emphasis on 21st century skills (cf. Bellanca & Ronald, 2010) in educational science and practice including skills like creative, critical, and innovative thinking stresses the need to investigate the cognitive level of the teacher-learner interaction more carefully.

Chi & Ohlsson (2005) provide a psychological framework that helps us track learning in terms of what they call re-representation: the learner is anything but a blank slate waiting to be filled with new information (see also Pinker, 2002). In contrast, learning takes place when the learner re-represents her existing knowledge.

Chi & Ohlsson (2005, pp. 376ff.) categorize these changes of knowledge along the following lines:

1) accretion: new information is added to existing knowledge
2) denser connectedness: as the learner acquires more knowledge, the connections between the knowledge elements become clearer and more sophisticated.
3) increased consistency: learning changes the knowledge base in ways that the integrated assertions can be true at the same time.
4) finer grain representations: learning often results in a refined understanding of things. The learner obtains more detailed information, here especially the parts things consist of.
5) greater complexity: this type of change results in the learner’s combining of two or more existing schema with a view to arriving at a knowledge representation of high complexity.
6) higher level of abstraction: with increasing expertise the learner tends to represent a problem at a higher level of abstraction. At
this abstraction level, thinking runs along deep principles and
generalizations rather than concrete surface components.
7) shifted vantage point: changing one’s perspective is another
psychological process which adds new information to one’s
knowledge base and thus scaffolds learning.

Defining learning in this way, the question must be posed how these
changes can be realized in the teacher-learner interaction. But before we
look into this question in more detail, I would like to draw the reader’s
attention to another important distinction: shallow vs. deep learning.

3. Deep learning

Understanding something on a deeper level includes much more than
adding information to one’s knowledge base. Especially changes 5)-7)
require the learner to form entirely new representations of a given problem
or state of affairs. In doing so, the learner has to overwrite or re-represent
prior knowledge, i.e. existing concepts are partly or fully deleted and
replaced by new ones. This is what Chi and Ohlsson (2005, p. 387) call non-
monotonic change.

These re-representations often involve abstract thinking. Abstract thinking
thereby goes beyond identifying common features of things and combining
those to higher level categories. Abstract thinking in the sense proposed
here already begins with abstract ideas (see also Ohlsson & Lehtinen, 1997).
These are eventually combined to larger schemas.

It is this kind of change which is at the center of deep learning. In the
following, I will lay out the basic design of a communicative model
for teaching and learning that revolves around non-monotonic changes,
particularly of the kind as stated in 5)-7). This model correlates deep
learning to communicative actions in the teacher-learner interaction. I call it
the explorative action game.

4. Teacher-learner interaction as explorative action game

Before we take a closer look at the model of the explorative action game,
let me say a few words about dialogic teaching and learning. Over the last decades, evidence has accumulated which shows that dialogic interactions boost learning and help the learner to process information on a higher level of thinking (cf., e.g., Benware & Deci, 1984; Deci & Ryan, 1985; Kage & Namiki, 1990; Koestner, Ryan, Bernieri & Holt, 1984; Vansteenkiste, Ryan & Deci, 2008).

The communication model that I propose grounds in Weigand’s Theory of the Dialogic Action Game (2002, see also 2010). The action game is the smallest functional unit of communication. It consists of an initial communicative action by one speaker and the subsequent reaction by the dialog partner (see Fig. 1).

This pair of communicative action and reaction is embedded within the speakers’ “worlds” incorporating cognitive, perceptive and also emotive states of the interlocutors, as well as their cultural backgrounds, societal norms, personal habits, preferences, and background knowledge.

Adopting the concept of the action game to teacher-learner interactions, we arrive at pairs of communicative actions and reactions that have learning as the main goal. We will take a closer look at the detailed structure of the game in the next sections, especially with regards to the particular speech act types and their functions. For now it is important to see that the explorative action game is a game of discovery. In this type of game, learning is not merely about conveying or comparing information. In contrast, teacher and learner explore a topic in collaboration. The teacher introduces the topic through the explorative speech act, for example, in the form of what I have called elsewhere “deep explanation questions” (Feller, 2013), which hint to a specific cognitive strategy. The learner follows this strategy and actively contributes to the interaction by processing information along its lines. She eventually shares her thoughts in the communication through the so-called
discovery speech act. I call this collaboration between the teacher and the learner in the explorative action game dialogic knowledge building (see also author, 2013 for more details on dialogic knowledge building).

4.1. The initial speech act: Exploring a topic
In this section we will look more closely into the function the initial speech act in the explorative action game (i.e. the communicative action), which I call explorative, has with reference to dialogic knowledge building (cf. Feller, 2013) and thus learning. What this means can be best illustrated against Searle’s (1969) formula F(p). F stands for the illocutionary function of the speech act, i.e. the purpose of the speech act or what the speech act is used for such as, for example, making a statement about the world, requesting information, or making a suggestion, among others. p is the propositional act, i.e. what the speech act is about. The propositional act itself consists of reference and predication. For example, a noun phrase like “my car” refers to a particular object in the world, which is represented as the concept [my car] in the speaker’s knowledge base. “is red” is used to predicate the color red to the concept [my car]. The car is ascribed with the property of being red.

Based on Searle’s formula, we can demarcate the following general structure for the explorative speech act:

EXPLORATIVE[TYPE OF CHANGE](topic) → communicative means (open-ended)

Fig. 2. The correlation between the function and the expression side. The explorative speech act is instantiated in language use by a potentially open-ended set of communicative means.

EXPLORATIVE in Fig. 2 denotes the illocutionary function of the speech act, which is in this case exploring a topic. More precisely, exploring is directed towards knowledge building via a specific type of knowledge re-representation as indicated by type of change in square brackets. These re-representations refer to Chi & Ohlsson’s (2005) types of changes discussed earlier which, in the explorative, are directed towards a specific topic presented in round brackets. The right side of Fig. 2 refers to how this speech act is instantiated in communication. As indicated by the arrow,
the speech act correlates to a potentially open-ended set of communicative means. These means include not only lexical expressions but also cognitive and perceptive means. For example, the speaker might refer to things in her environment and elicit inferences with reference to given background knowledge that is not expressed verbally. In addition, as Weigand (2010) has pointed out, speakers can invent new communicative means \textit{ad hoc} or overwrite existing conventions in a given situation. This is why it is elementary to work out the function side of the teacher-learner interaction. It is the function side which helps come to grips with the ever-changing side of communicative means.

### 4.2. The reactive speech act: Discovery as knowledge re-representation

Having arrived at the functional demarcation of the explorative speech act, we can now take a closer look at the reactive speech act: the discovery speech act. Following Searle’s formula once more, we represent this speech act as follows:

\[
\text{DISCOVERY}[\text{TYPE OF CHANGE}](\text{re-representation}) \rightarrow \text{communicative means (open-ended)}
\]

**Fig. 3.** The correlation between the function and the expression side. The discovery speech act is instantiated in language use by a potentially open-ended set of communicative means.

The illocutionary function of this speech act is \textit{discovery}, meaning that the speaker changes her existing knowledge, thus arriving at new knowledge in terms of re-representations as discussed in section 2. As a reaction towards the explorative speech act, this speech act is about engaging in higher level thinking by abstracting and combining abstract ideas to complex schemas. These schemas are thereby directed by the particular type of change introduced in the explorative speech act. Again, just like for the explorative speech act, the set of correlating communicative means is potentially open-ended.

### 4.3. Selected types of explorative action games: non-monotonic change

Now that we have set the scene, let us take a look at selected action games of non-monotonic change. I will focus on Chi & Ohlsson’s types 5)-7). In
the following, each of these types will be correlated with a corresponding explorative action game. The starting point for the construction of the action games are selected passages from school textbooks. These passages apply linguistic means that are used to instantiate a particular non-monotonic type of change.

At this point it is worth to note that the difference between text and speech is irrelevant for our purposes. What is important here is the communicative function of the text, not the medium of communication. The textbook passages could just as likely be part of the teacher’s speech. In all cases, they are in the role of the explorative speech act in the action game and are thus an appropriate data pool in this context.

4.3.1. The game of greater complexity
Following our definition in 5), let us look into the design of an explorative action game for greater complexity. For this purpose, we should answer the following questions:

a) How are re-representations triggered by the explorative speech act in the game?

b) How does the game guide the learner towards higher level thinking and deep learning?

Both a) and b) must be answered from within the explorative action game. In this context, we want to find out which communicative means map onto deep learning and how these means “manipulate” the learner’s cognitive processing of a given problem or topic.

4.3.1.1. Metaphor as complexity scaffold
In the coursebook Mental Maths Strategies: Year 1 (2005) the mathematical operation of addition is defined as follows:

1) “Addition is joining together of two or more groups of objects (or numbers).” (p. 2)

Furthermore, we read about multiplication:
2) “Multiplication is repeated addition of equal groups of rows or objects (or numbers).” (p. 4)

Both definitions follow the basic construction A is B, where A is the tenor, i.e. the object to which attributes are ascribed, while B is the vehicle, i.e. the object from which attributes are borrowed. It is thereby important to note that A is B is not an identification statement; rather, we are dealing here with what we could call partial identification. It is only a specific set of attributes which are projected onto the tenor.

My claim here is that the metaphorical definitions help the learner to process the presented information on a higher level of thinking. The metaphors scaffold a re-representation of what is presented in terms of a complex theory of quantity. This is only possible because the learner operates on abstraction. More so, the learner’s processing of the metaphors requires that she uses abstract representations of the mentioned entities from the very beginning.

This game can be represented as follows:

Fig. 4. Metaphor as complexity scaffold. Metaphor is used as a communicative means to guide the learner to a re-representation of the topic “multiplication”. The utterance under the discovery speech act is an invented example for illustration purposes.

What does this mean exactly? Well, it means that the learner conceptualizes multiplication by combining her schema of addition with her schema of repetition. Both these schemas are already abstract and eventually combined to the new, more complex schema of multiplication.

4.3.1.2. Irony as complexity scaffold
As I argued elsewhere (Feller, 2008), irony can be used to persuade people
to take a specific course of action. This can also be applied to a “cognitive course of action”. In this sense, irony can be used to lead the learner to think in more complex schemas by combining some of her already existing schemas. Consider the following example:

3) Now, since we found the God particle, God must be the creator of the universe.
(http://www.americanthinker.com/blog/2012/07/does_the_god_particle_prove_that_god_does_or_does_not_exist.html, last date of access 27 Nov. 2013)

Detecting and interpreting the irony in 3) is based on a complex re-representation of the question of God’s existence and the origin of the universe. The irony of 3) combines three distinct schemas:

i) God is the creator of the universe.
ii) The universe is accidental.
iii) Something can come from nothing. The universe might have sprung from a “purposeless quantum burp in space”. (http://www.americanthinker.com/blog/2012/07/does_the_god_particle_prove_that_god_does_or_does_not_exist.html, last date of access 27 Nov. 2013)

We can represent the correlating type of explorative action game as follows:

![Diagram](https://via.placeholder.com/150)

**Fig. 5.** Irony as complexity scaffold. Irony is used as a communicative means to guide the learner to a re-representation of the topic “beginning of the universe”. The utterance under the discovery speech act is an invented example for illustration purposes.
By processing the irony of 3), the learner takes these three schemas and combines them to a schema of higher complexity: the ironic reading renders the verbally expressed schema i) as absurd, while ii) and iii) remain as plausible alternatives. The evaluation triggered by the ironic mode provides new combinatorial properties for the formation of the complex schema. Without it, the attempt to combine the single schemas would result in a conflict between i), on the one hand, and ii) and iii), on the other hand, which would abruptly end the reasoning process.

4.3.2. The game of higher level of abstraction
Following 6), it is again the two questions a) and b) which lie at the heart of designing the action game. In this case, the action game prompts a re-representation in terms of higher order principles that go beyond material features of concrete objects.

4.3.2.1. Simile as abstraction scaffold
In the coursebook *Mental Maths Strategies: Year 1* (2005) the following similes, among others, are used to teach geometric shapes:

4) “A diamond (or rhombus) is a plane shape with four equal sides but without a right angle. It looks like a flattened square.” (p. 9)
5) “An oval is a plane shape that has a curved line as its boundary. It looks like a flattened circle.” (p. 9)

Taking a closer look at 4) and 5), we can see how analogy directs the learner to think in more abstract terms about the geometric shapes introduced. Both diamond and oval are compared to flattened versions of the more basic geometric concepts square and circle respectively. The simile leads to an abstraction along the general pattern \texttt{PARTICULAR SHAPE = FLATTENED(BASIC SHAPE)}. This pattern leads to further knowledge building: for example, the distance between the points on the sides of a shape and the center point varies with the varying degrees of being flattened. Following this conceptualization, the learner can easily construct a potentially endless number of new shapes, not being restricted to any particular instance.

Take a look at this representation of the game:
4.3.2.2. Metonymy as abstraction scaffold

Consider the following metonymies in *Mental Maths Strategies: Year I* (2005, p. 12):

6) “We use several different types of clocks to tell the time.”
7) “Analog clocks use hands to tell the minutes and hours.”

The metonymy in 6) is *totum pro parte*, i.e. the whole, in this case the clock, stands for those parts of the clock that show time including the display, the scale, the hands, and furthermore the angles between the hands, among others. In contrast, 7) is *pars pro toto*. The hands as part of the clock refer to the scale, the hands, and the angles between the hands corresponding to their position on the scale.

In both 6) and 7), thinking is directed towards abstraction. In the *totum pro parte* reading, the learner abstracts from the particulars of the described object. Her representation is on the level of the whole, which makes it easier to connect it to other representations with a view to forming more complex schemas. Likewise, *pars pro toto* reduces complexity by widening the meaning of the part or component and therewith accentuating and directing the learner’s focus. She does not have to conceptualize all the parts and their interactions but can now focus on a specific part which is emphasized by the metonymical expression.

In this action game, metonymy, more precisely the *pars pro toto* topos, guides the learner towards the “angle reading” of the clock as time display. The focus is shifted on the hands, leaving out the other parts that are involved in the clockwork. As such, the learner manages to combine this
abstract schema with her schema of restricted visual perception, bringing them together to a more complex schema of reading the time by the angles between the hands.

4.3.3. The game of shifted vantage point
As defined in 7), the game of shifted vantage point is about changing one’s perspective when processing a topic or problem. Changing one’s perspective is thereby not restricted to the perspective of a person; in other words, this does not necessarily mean considering a problem through somebody else’s eyes. Changing one’s perspective might also refer to one’s viewing a problem from a different angle, i.e. applying a different cognitive strategy when processing a problem or topic.

4.3.3.1. Quasi-synonyms as vantage point shifter
*Mental Maths Strategies: Year 2* (2005) provides an example:

The mathematical operation of dividing is explained along two different concepts: sharing and grouping. The linguistic function which is put to use here is that of quasi-synonymy:

8) “You can share objects by using the ‘one for you, one for you [sic?], and one for me’ method of sharing.” (p. 5)
9) “We place objects into groups of 2 [i.e. for dividing by 2] and then count the number of groups.” (p. 5)
Quasi-synonyms like “share objects” and “place objects into groups” share a common core meaning but also show some important semantic differences. In the case of 8) and 9) the core meaning can be described as “splitting up a larger group of objects”. The difference between 8) and 9) lies in the exact type of splitting: while the sharing reading of 8) adds objects in a fair cycle to n groups of equal size, the grouping reading of 9) requires splitting up the group of objects into n groups of equal size. Switching between these two strategies helps the learner solve problems that revolve around different kinds of distribution:

**Fig. 8.** Quasi-synonymy as shifted vantage point scaffold. Quasi-synonyms are used as a communicative means to guide the learner to a re-representation of the topic “division”. The utterance under the discovery speech act is an invented example for illustration purposes.

4.3.3.2. Narrative markers as vantage point shifter
Another way to help the learner re-represent a given problem is by clothing information in narrative terms. In the textbook *Maths: The basic skills* (2004) fractions are introduced through short word problems of the following kind:

10) “A recipe for macaroni and cheese for 6 people includes these ingredients: 300g cheese 120g butter [...] Suppose there are only 4 people. [...] You need $4/6 = 2/3$ of the quantities.” (p. 84)

Word problems like this make the learner associate the provided information with concepts from a real-life context. In this particular case,
fractions are applied to amounts of cooking ingredients. The learner can imagine measuring the “real” ingredients, breaking them up into smaller portions and combine these to the amounts stated in the recipe.

Shifting the vantage point from abstract numbers to real world objects scaffolds the learner’s processing of the underlying problem. The descriptive language of word problems, especially the real word references and the use of mental verbs like “suppose” work as cues that tell the learner to take on a different perspective.

Another example comes from the geography textbook *Explore Geography 2* (2006). The chapter called “Changing Environment” is divided into smaller subsections: “At the Local Scale”, “At the Regional Scale”, and “At the Global Scale” (pp. 85-87). This perspectivization along distinct levels of environmental change is carried over to the subsequent subsection on “Protecting and Conserving the Environment”, where counterstrategies to pollution are viewed along “Individual Actions”, “National Actions”, “Regional Actions”, and so on (pp. 88ff.). The language throughout these sections directly refers to these different levels. The paragraphs are introduced by adjuncts like “At the national level” (p. 89). In addition the use of personal language differs between the taken perspectives. While the section on the individual level frequently uses “we” and “our”, the collective perspectives do not feature first person pronouns, actually not any pronouns at all. The tone is kept factual. The learner is prompted to change her perspective along these lines, tackling the topic by switching between the individual and the collective, the personal and the

**Fig. 9.** Narrative markers as shifted vantage point scaffold. Narrative markers are used as a communicative means to guide the learner to a re-representation of the topic “changing environment”. The utterance under the discovery speech act is an invented example for illustration purposes.
anonymous, as well as the immediate and the distant.

Shifting the vantage point throughout problem solving, the learner can merge the specific aspects of the different perspectives. She can crosslink features across the presented scales of environmental change and combine them to a complex schema that grasps potential interactions between the scales.

5. Conclusions

We have conceptualized teacher-learner interactions in terms of explorative action games. The novel contribution of this paper is thereby that the presented action games structure language for dialogic knowledge building, correlating speech act functions with the non-monotonic types of change “greater complexity”, “higher level of abstraction”, and “shifted vantage point”.

In the teacher-learner interaction, the teacher scaffolds the learner’s discovery of new knowledge via explorative speech acts. The learner responds with a discovery speech act, in which she communicates how she has changed her existing knowledge.

If the hearer in fact changes her existing concepts, is contingent on a variety of factors that lie beyond the immediate scope of the communicative means applied in the action game like the exact make-up of the learner’s existing knowledge base, her learning preferences and her abilities. For future research, it will be essential to pinpoint these other factors and understand how they exactly affect learning. Only then can learning as discovery be described comprehensively. New insights here will open up a number of possibilities to make teacher-learner interactions more fruitful and enjoyable by tailoring communicative strategies to the individual needs of the learner. I am confident that the model of explorative action games is a first starting point in this direction.

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