Divergent and Convergent Knowledge Processes on Wikipedia

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Abstract: The paper presents a new theoretical consideration of knowledge processes bridging the individual and the collective level. Building on a differentiation between accommodation and assimilation of knowledge in wikis, we derive divergence and convergence from intelligence and creativity research and reconstruct their impact on the open-ended development of knowledge. The distinction from related CSCL constructs is elaborated. Using examples from Wikipedia, the definition of divergence and convergence is illustrated in the dynamic context of article development.

Introduction

Research on CSCL is marked by different emphasis of individual and collective knowledge presenting a challenge of integrating the theoretical concepts. Sfard (1998) has proposed a well-known differentiation between two basic approaches, the knowledge acquisition metaphor and the participation metaphor. The former metaphor refers to models that may acknowledge social factors in the learning process, but focus on how individuals develop certain cognitive structures and acquire understanding. The latter metaphor concerns models of knowledge as a collective phenomenon that emerges from people's activities, situated in a socio-cultural context, and cannot be reduced to single contributions (Stahl, 2006).

Paavola, Lipponen and Hakkarainen (2004) have introduced a third metaphor that goes beyond Sfard's dichotomy in order to describe models of long-term *knowledge creation*. The theory of *knowledge building* (Scardamalia & Bereiter, 2006) belongs to this perspective and illustrates how communities can create knowledge collaboratively by an ongoing incremental advancement of shared dynamic artifacts. Artifacts such as explicit ideas at the same time mediate and coordinate the interaction between collaborators. The exact knowledge processes between individuals and mediating collaborative artifacts are addressed by the *co-evolution model* (Cress & Kimmerle, 2008) transferring some of Piaget's (1983) ideas to the context of social software and wikis in particular. Knowledge incongruities between the mediating artifact system of a wiki and the cognitive systems of its users are suggested to create a cognitive conflict that is resolved through the processes of assimilation and accommodation. Assimilation means that new information is received and customized to fit the prior knowledge. Accommodation, accordingly, means that new information leads to structural changes of the prior knowledge. The predicted outcome of the model is individual learning – internalization – or a change of the information in the wiki – externalization.

"Knowledge creation" models deal, compared to the other two metaphors, in the most explicit way with the interaction between individual and collective knowledge. They are best suited to give a more accurate account of how collective knowledge emerges from the collaboration of a large number of individuals. This form of collaboration has become more common as a result of the emergence of Web 2.0 technologies, with Wikipedia being the most remarkable example (Halatchliyski, Moskaliuk, Kimmerle, & Cress, 2010). We consider the postulated equivalence of assimilation and accommodation processes at individual and collective level as a very interesting research question for CSCL. In this paper, we will elaborate on the equivalence, introducing the processes of divergence and convergence as complementary to the assimilation-accommodation perspective. We will explain the origins of the concepts and differentiate our understanding against other usages of these terms in the field of learning sciences. For the sake of concreteness, we will provide some illustrative examples from Wikipedia, the Online Encyclopedia.

Knowledge Processes of Convergence and Divergence

Regarding the perspective of an *individual*, the convergence and divergence opposites were first described by Guilford (1950). He later included them as dimensions of thinking into his model of intelligence (Guilford, 1967) contrasting the identification of a single correct solution to a problem with the generation of many different possible alternatives. At about the same time, Hudson (1966) described the opposites as different cognitive styles, correlating with the different abilities of students in science and arts. This started a controversy about the connection of both styles with intelligence and creativity. Convergers were described as people who tend to analyze systematically, evaluate critically and deduce logically one feasible solution. Divergers were supposed to be intuitive explorers of ideas in multiple frames. Later it was concluded that these styles were not a stable personal characteristic and better seen as modes of thinking (Robertson, 1985). Creativity researchers also acknowledged the need to achieve a balance between both complementary modes in order to obtain relevant and, at the same time, original solutions or products (Levine & Moreland, 2004).

Convergence and divergence have also been discussed in the context of *group* creativity and decision making. Brainstorming and other creativity techniques are widely applied and aim at facilitating divergent thinking and development of innovative ideas. Otherwise, the full solution to a problem often demands the choice and implementation of a single best idea. Janis (1982) has shown that this process of convergence in groups may be very erroneous, coining the term groupthink.

Creative processes in groups have a long tradition of being divided into divergent and convergent *phases* (Finke, 1992). In the context of CSCL, Onrubia and Engel (2009) noted that many researchers have also defined various numbers of stages of the joint creation of knowledge. Convergence is supposed to occur at a later moment after people have shared knowledge, identified differences and negotiated common understanding. Fischer and Mandl (2005) found that convergence is beneficial to learning. Other researchers have proposed the implementation of *scripts* that guide the process by dictating a sequence of joint activities (Dillenbourg, 2002). The reason why more attention is paid to convergence than divergence is the view that constructing shared understanding is the main goal of collaborative learning (cf. Roschelle, 1992). A knowledge building discourse is not an argumentative debate, where people try to defend different opinions, but it aims at collaboratively advancing ideas and reaching commonly accepted solutions to problems (Scardamalia & Bereiter, 2006).

The above results apply best in those settings in which small groups of people collaborate on solving a restricted problem with constraints on time, goals, or solution approaches. Observations in different settings (cf. Liu & Wang, 2010) show that convergence and divergence can repeatedly occur and complement each other during different stages of group interaction. Jorczak (in press) also challenged the idea that convergence alone is beneficial for learning. He emphasized the need for cognitive conflict within and among group members based on divergence, so that improved learning and knowledge can be achieved upon conflict resolution. Another recent analysis of knowledge building in school classes (Zhang & Messina, 2010) confirms the equivalent importance of both the accumulation of variable ideas as well as their critical examination.

In the present work, we deal with a mass collaboration setting, as in the case of the open-ended project Wikipedia. We apply these concepts to a dynamic knowledge artifact, a wiki, where diverging understanding can also be expected at later stages of collaborative knowledge creation. The co-evolution model (Cress & Kimmerle, 2008) offers a good theoretical starting point, as it is geared to the learning context of wikis. It describes assimilation and accommodation as two processes of adaptation of an individual or a wiki, following the experience of a cognitive conflict. Referring to wikis, assimilation is defined as the addition of information at a suitable place, without establishing new connections that would change the structure of the wiki. Accommodation means a distinct change of the knowledge organization through rearrangement of paragraphs and pages, which results in a new focus. Both processes are compatible, often appear together and concern the question of structural changes in the wiki (Moskaliuk, Kimmerle, & Cress, 2009).

Divergence and convergence, the processes in the focus of the current discussion, are not derived from Piaget's theory, and represent a different categorization of knowledge creation. So the essence of divergence and convergence shows itself not in the way *how* new information is integrated – as in the case of assimilation and accommodation –, but in the *qualities* of this new information, compared to the available knowledge. So we see these two categorizations of processes as independent from each other.

We define the characteristics of the new processes in a wiki on the lines of the definition of divergent and convergent thinking at an individual level. Divergence is present when a new idea is added that opens a new direction for addressing the problem of a specific article page. This may be new information that cannot be categorized under the available viewpoints, an alternative explanation, or it may be a new way of describing the issue. Convergence refers to acts based on critical evaluation and logical reasoning. Here, the result is not so much the addition of new aspects as the establishment of a coherent structure of the presentation. This may be done by subsuming some of the new or already available major points under a common category, through abstracting a model or principle, or through eliminating a conflicting issue. Some actions, like corrections of simple mistakes, may not be categorized in this schema, and some other actions may contain elements of both processes. The categorization may also be applied to analyses with different granularity, for example, at the level of an article, at the level of a connected group of articles like a wiki category, or at the level of a whole knowledge domain like a network of categories and articles. Complex actions may be both converging and diverging at different levels at the same time. For example, the movement of a section from an existing article into a new article would represent a convergence for the old article and a divergence for the set of articles that both the old and the new article belong to.

This new categorization schema is not a substitute for the accommodation-assimilation perspective. A single change may, for example, be a case of accommodative restructuring that resolves a conflict in a wiki, and at the same time it may be classified as divergence or convergence or neither of these. Using dynamic social network analysis, Kimmerle, Moskaliuk, Harrer und Cress (2010) have given an example of high level processes concerning a set of articles about schizophrenia. The researchers identified accommodative reorganization of clusters of article on different explanatory approaches to the mental disorder. Articles on two

of the approaches merged into one tightly interconnected cluster – in our view another example of a higher-order convergence process.

As with the assimilation-accommodation dichotomy, we describe here two complementary processes regulating the development of both individual and collective knowledge. In the following section we will provide an illustration of the differentiation between assimilation, accommodation, divergence and convergence, using the edit history of the English Wikipedia article on *Knowledge* (1).

Wikipedia Examples

The following examples are reported chronologically and reflect the starting period of the article *Knowledge*. Each case is chosen to show one of the eight possible occurrences of the independent categories, assimilation, accommodation, divergence, convergence, and their combinations.

The article was started on 20th August 2001 as a lecture on philosophy of nearly 4000 words. Its main point was that "Knowledge is justified, true belief." In the first example a short general definition was added at the head of the long lecture on the 30th of July 2002:

> *Knowledge is those descriptions, assertions, concepts, formulations and procedures which to a reasonable degree of certainty are either true or useful.*

This change could be interpreted as divergence, because *usefulness* was a new idea introduced in the article. At the same time, it is not assimilation, as the change does not follow the previous pattern of exposition. It could also not be seen as accommodation, because the definition appears detached from the long lecture and does not meaningfully change the overall structure of the article and the overall concept of *knowledge*.

In our second example, the definition was extended on 5th and 15th September 2002 to differentiate a *factual* and an *inferential* type of knowledge, as well as the knowledge sources *authority, reasoning* and *experience*:

> *Knowledge may factual or inferential. Factual knowledge is based on direct observation. It is still not free of uncertainty… Inferential knowledge is based on reasoning from facts or from other inferential knowledge such as a theory. It may or may not be possible to verify by observation or testing.* (sic)

> *"… three ways in which men think that they acquire knowledge of things - authority, reasoning, and experience …"*

The new changes resemble the previous example and could be interpreted as divergence. After the addition of the new paragraphs, the lecture was not displaying the only perspective on *knowledge* any more. Although the connection between both paragraphs is not quite obvious, and a common new direction for the article is difficult to be determined, accommodation has seemingly started to take place. Compared to the previous example, the topic of the article was receiving a different shape and meaning.

The third example displays a new paragraph from 19th September 2002 that provided a new organization for the ideas from the last example:

> *Knowledge consists of beliefs about reality. One way of deriving and verifying knowledge is from tradition or from generally recognized authorities of the past, such as Aristotle. Knowledge may also be based upon the pronouncements of secular or religious authority] such as the state or the church. A second way to derive knowledge is by observation and experiment, the scientific method. Knowledge may also be derived by reason from either traditional, authoritative, or scientific sources and may or may not be verified by resort to observation and testing.* (sic)

We chose this as an example of convergence, because it presents a new systematics that encompassed already available ideas from different paragraphs, and consolidated them into a single picture. The concept of *belief* was mentioned and connected the whole introductory part to the lecture part. The processes of *deriving* and *verifying* knowledge were stated, and an overview of different ways was provided. Accommodation was also present at this moment, because the article obviously had a new structure – a beginning with definitions and classifications, and a longer easy-to-read discussion.

Our fourth example refers to relativizing statements that were added on 18th April 2003:

> *What constitutes knowledge, as well as truth and utility, is often contentious and debated by phisilophers, social scientists, and historians.* (sic)

We tend to interpret this as a pure accommodation, because, here, the concept of *knowledge* is placed into a new and broader context. The change is based not on new alternative ideas (no divergence) and not on

new conclusions from available knowledge (no convergence). The same is true of the revision on 20th April 2003, when the sentence "*Knowledge is...*" was changed into "*Knowledge includes, but is not limited to...*".

The fifth example shows how some essential ideas from the lecture were paraphrased on 9th May 2003. The main points were abstracted from many examples brought up to facilitate the lecture. The lecture part itself could then be safely deleted on 18th May 2003.

> *Conventionally, knowledge is defined as a justified, true belief. "Justified" means that one has some evidence supporting the belief. "True" conventionally means something like this: one could make plans based on a true belief, and they would not fail.*
>
> *Every part of this definition can be, and has been attacked. There are problems with the objectiivty, adequacy and limits to justification. There are problems with various definitions of truth...* (sic)

Although the structure of the whole article changed, this transformation is not a case of assimilation or accommodation as no new information was added to the article. This is a simple form of convergence.

The sixth example deals with changes stressing the *scientific method* on 25th May 2003:

> *The only way to gain reliable knowledge about the physical world that we live in is though the scientific method. ... A scientist picks one question of interest, and basdd on all previous information and experience, develops a hypothesis...* (sic)

Here, as we see it, joint convergence and assimilation took place. The contributor singled out *scientific method* as the main way of deriving and verifying reliable knowledge, compared to following authorities or logic (convergence of alternatives). At the same time, a description of details of the scientific process was added, which did not change the notion of knowledge (assimilation of new information). So, without changing the structure of the whole exposition, the new revision placed one available aspect more into focus.

The seventh revision example concerns a short reference added on 5th June 2003:

> *What constitutes knowledge, certainty, truth and utility, are deeply contentious and debated by philosophers... As just one example, Ludwig Wittgenstein wrote "On Certainty" ... exploring relationships between knowledge and certainty.*

The change represents a case of assimilation alone, because it only added information that fitted the available exposition. It did not introduce new alternative concepts (no divergence), did not establish new connections (no convergence), and did not change the structure of the knowledge article (no accommodation).

The last example here shows a sentence from the same revision on 5th June 2003 that added a new perspective on *beliefs* and their potential for action (the part outside of the brackets):

> *[Most people can produce descriptions of beliefs, at least when they're asked a relevant question,] but perhaps not state their limits so clearly as to know reliably when that belief is actionable and when not.*

The change tends to express simultaneous divergence and assimilation. While the sentence was meant to describe an alternative idea, this divergent idea was assimilated and did not have an impact on the overall concept of *knowledge*.

These eight cases consider knowledge processes at the scale of a single article. As previously mentioned, the processes of interest can be identified also from the broader perspective of sets of articles. For instance, the same article *Knowledge* was split into two articles, *Knowledge (philosophy)* and *Propositional knowledge*, on 10th June 2003. On 14th April 2004 *Knowledge (philosophy)* was re-incorporated into the new *Knowledge* article. Such movements of paragraphs or whole articles can be studied as processes of divergence and convergence, in order to identify evolution patterns of a broader topic and also the co-evolution with different groups of contributing authors.

Conclusion

The Wikipedia examples were chosen to characterize the nature of both processes of convergence and divergence in collective knowledge, and to differentiate them from the processes of accommodation and assimilation, as postulated by the co-evolution model. It is obvious that this identification is susceptible to interpretations. Compared to the relatively simple examples here, there may be complicated cases where divergence and convergence may occur simultaneously. Nevertheless, we believe that the new categorization bears a potential for grasping analyzing detailed mechanisms of mass collaboration, as in the case of Wikipedia.

The examples showed that convergence and divergence processes alternate with each other in the course of article development. It is possible to classify very detailed changes at the level of a single article and also at the level of groups of articles, so a coarse-grained study is also feasible. As a future direction for

research, we would like to show how detailed studies of these processes can help answering particular questions concerning the development of single articles or whole knowledge domains of connected articles.

Endnotes

(1) The article history until the 10th of June 2003 is accessible at: [http://en.wikipedia.org/w/index.php?title=Descriptive_knowledge&action=history&year=2003&month=6]. It has remained with an older version of the article that was later renamed to Descriptive knowledge.

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