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# Individual Learning and Collaborative Knowledge Building with Shared Digital Artifacts

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***Abstract*—**The development of Internet technology in recent years has led to a more active role of users in creating Web content. This has significant effects both on individual learning and collaborative knowledge building. This paper will present an integrative framework model to describe and explain learning and knowledge building with shared digital artifacts on the basis of Luhmann's systems theory and Piaget's model of equilibration. In this model, knowledge progress is based on cognitive conflicts resulting from incongruities between an individual's prior knowledge and the information which is contained in a digital artifact. Empirical support for the model will be provided by 1) applying it descriptively to texts from Wikipedia, 2) examining knowledge-building processes using a social network analysis, and 3) presenting a survey of a series of experimental laboratory studies.

***Keywords*—**Individual learning, collaborative knowledge building, systems theory, equilibration.

## I. Introduction

In recent years, one could witness a fast development of the Internet. New technologies and services, so-called Web 2.0 tools, like wikis, weblogs, podcasts, folksonomies, file sharing and virtual online worlds are changing their users' handling of data, information and knowledge [1]. Users are now actively involved in creating Web content. The distinction between consumers and producers of knowledge will not make sense any more. Content is linked beyond the limitations of single tools or applications by using open interfaces. The desktop computer as an individual's repository tends to be replaced by the Web [2].

This development will have a strong impact on individual learning [3]. Individuals now have the opportunity to participate in a collective development of knowledge and, at the same time, benefit from a vast amount of knowledge which is available world-wide. Learning – as defined by constructivism – is intensified by what is offered through the Internet: individuals participate in self-regulated learning in informal learning spaces, as members of a community of knowledge. The world-wide availability of (mainly free) social software tools has opened up a new dimension of knowledge processes: large numbers of users can work jointly on shared digital artifacts [4]. This will not only lead to cumulation of knowledge, by which the knowledge of many individuals is brought together and made available to others, but also to emergence, the creation of new knowledge [5], a process that is being discussed using keywords like "Wisdom of the crowds" [6], [7].

Practice with many Web 2.0 applications has shown, however, that new knowledge will by no means be generated automatically by large numbers of collaborating users. Social software environments will not in all cases lead to the optimum of an individual learning process, and it is quite infrequent that new knowledge is actually being generated within the community. So the question is under which conditions these emergent phenomena do occur and Web 2.0 tools can actually become catalysts of knowledge progress.

In order to describe processes of knowledge progress and the circumstances that facilitate it, a framework model will be provided that aims at describing and explaining processes of learning and knowledge building with shared digital artifacts. This model is based on Luhmann's systems-theoretical approach [8] as well as on the model of equilibration by Piaget [9]. The following section II will present the framework model, starting with a brief outline of the underlying approaches and then describing our model. Section III will discuss empirical evidence for the validity of this model, based on content analysis of Wikipedia articles. Section IV describes co-evolution of cognitive (individual learning) and social systems (collaborative knowledge building), also citing an example from Wikipedia. Findings from experiments under laboratory conditions will be presented in section V. The article will conclude in section VI with a summary and discussion of our considerations and findings.

## II. Basics of Learning and Knowledge Building

The framework model which is presented in this section is based on systemic and cognitive considerations to describe processes of collaborative knowledge construction. Based on a systems-theoretical approach, the model describes shared

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Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf

artifacts and their respective communities as social systems as defined by Luhmann [8]. In order to describe those processes that change this social system and the cognitive systems of individual users, the model refers to Piaget's concept of equilibration [9]. The following paragraphs will, therefore, first give a brief outline of Luhmann's and Piaget's approaches before presenting Cress and Kimmerle's integrative framework model [10], [11].

### *A. Luhmann's System Theory*

The basis of Luhmann's theory is the distinction between "system" and "environment" [12]: whatever is not part of the system belongs to its environment. So a system is defined by the boundary between itself and other systems which form its environment. A system consists of operations which create the difference between the system and its environment [13]. Communication is the mode of operation of a social system. Cognitive systems operate via processes of consciousness and cognitive processes. Systems are autopoietic [14], cf. also [15]. They are capable of self-production and self-reproduction, thus guaranteeing their own existence [16].

The nature of a system is such that it is not in an immediate exchange with its respective environment, but "operatively closed". This operatively closed character of a system excludes communication between autopoietic systems, as these operate in different modes. But one can still observe that a system is influenced by other systems and reacts to its environment. Luhmann has solved this problem by stating that a system is both open and close, using the concept of structural coupling [17]. Structural coupling is based on the structure of expectations that the system creates, which make it sensitive to irritations from other systems, i.e. the environment of that system. Irritations from the environment will be transferred into that mode of operation which is inherent in that system. This may result in a "structural drift", which appears as if one system had interfered with another system, or as if the system environment had interfered with the system.

From the point of view of the system, the environment will always be more complex and more chaotic than the system itself. The system will reduce this complexity by using a binary code that distinguishes what belongs to the system and what does not. The binary code is a safeguard to keep the system operatively closed. At the same time, reduction of complexity is a requirement of emergence [18]. Emergence refers to systems with hierarchical structure in which features may occur at the higher level of the system which cannot be explained by features of the lower level of the system. These features which exist at a higher level are created by reciprocal action (synergy) between elements at the lower level of the system. Only this holistic consideration makes it possible to explain phenomena of emergence; this will not be achieved by a reduction into partial systems or subsystems.

Luhmann's theory is capable of describing computer-mediated construction and communication of knowledge. Digital artifacts and their respective communities may be understood, in Luhmann's terminology, as social systems that use written communication as their mode of operation. Communication is mediated, using a digital artifact, and the system is structurally coupled with the cognitive systems of its users.

### *B. Piaget's Theory of Equilibration*

While Luhmann's emphasis is on social systems, other constructivist theoreticians are more interested in psychological aspects. One constructivist approach that is particularly relevant in order to understand learning is that by Piaget. This approach describes a concrete example of a cognitive system that has to deal with "irritating" information from the environment. Piaget describes qualitative changes of cognitive schemas in the course of an individual's development [19], [20]. A cognitive schema gives a structure to and simplifies stimuli from the environment and helps the individual to understand them. Knowledge is, according to Piaget, always a construction of one's environment, or, in other words, an interpretation of one's experience of the environment, using individual cognitive schemas.

Knowledge construction, then, is an increasingly more flexible application, modification, and adaptation of cognitive schemas. According to Piaget, the mechanism is as follows: an individual's experiences with the environment may lead to perturbation of this individual's cognitive balance ("equilibration") or, in other words, to a cognitive conflict. This individual's own cognitive schemas will no longer fit his or her experiences with the environment, requiring adaptation. Here, Piaget makes a distinction between two functions: assimilation and accommodation.

Assimilation means active shaping of the environment by interpreting and explaining current experiences, giving them a place in existing schemas; accommodation means adaptation to the environment in the form of qualitatively changing one's own cognitive schemas.

### *C. Integrative Framework Model by Cress and Kimmerle*

An integration of the constructivist and systemic approach is achieved by Cress and Kimmerle's framework model [10], [11], [21]. The authors have explained their model of knowledge construction by referring to wikis as a concrete example or prototype of a shared digital artifact. They distinguish between two systems in Luhmann's sense: the social system (content of the wiki and the associated community) and the cognitive system of an individual, meaning this person's declarative knowledge in semantic memory [22]. These two systems cannot simply be transferred into each other, because they are both operatively closed. But they can both be developed further by structural coupling. This structural coupling is made possible by the processes of exchange that occur between the social system wiki and the cognitive system of the individual.

Here a distinction needs to be made between internalization and externalization of knowledge. In the course of externalization, a user will supplement or modify a wiki

Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf

article on some topic by using his or her own knowledge. Then this knowledge exists independently of that user in the form of information that anyone can read in the wiki. This externalization process will not only lead to an increase of information in the social system wiki, but also requires some growth of knowledge in the individual user's cognitive system. Externalization of one's own knowledge requires that a person deals in more depth with existing knowledge structures and considers them more thoroughly [23], and this will lead to an improvement or re-alignment of cognitive schemas. Writing such texts and working with them become tools for individual knowledge acquisition [24].

The second process is internalization of information from the wiki. Pieces of information from the wiki are decoded and integrated into existing internal knowledge structures. This will create new knowledge entities in that person's cognitive system, new associations between knowledge entities and new schemas.

Cress and Kimmerle's model specifies the mechanisms of internalization and externalization and expands Piaget's model by describing accommodation and assimilation not only from the perspective of an individual's cognitive system, but also from that of a social system. Users assimilate information from the artifact into their own cognitive schemas, and they accommodate by modifying their schemas induced by information from the wiki.

An analogous process of assimilation may take place in the wiki: users add pieces of information from their own knowledge, which will, however, not change the basic message and structure of the wiki, only add additional aspects. But accommodation is also possible in a wiki if users contribute their knowledge in such a way that the entire message is changed completely and, sometimes, new structures are being created. Accommodation tends to bring about some qualitative modification of the artifact and cognitive schemas, whereas assimilation has to do with quantity, introducing new arguments or examples but no fundamental innovation.

As a result of the processes of internalization and externalization, both the cognitive systems of the individuals involved and the social system wiki will develop further. Both systems will mutually influence each other, and as a result of the difference between the two systems (in Luhmann's terminology: the boundary between the systems) new knowledge will be generated. What happens is co-evolution of the two systems, which can be regarded as the result of structural coupling. The newly generated knowledge is emergent because it was previously neither part of the cognitive system nor of the social system, but can only be explained by looking at both systems simultaneously, cf. also [25].

## III. Content Analysis of Wikipedia Articles

Cress and Kimmerle were able to demonstrate, citing various Wikipedia articles as examples, what these processes of assimilation and accommodation, as described above, can mean in practice for a shared digital artifact [11]. Processes of equilibration may, for example, be observed in the English-language Wikipedia article on "AIDS origin". This topic is a matter of controversial discussion, which finds expression in a large number of alterations on the Wikipedia page. These consist both of assimilations and accommodations. An assimilation, for example, is the following modification which simply adds an item to a list of abbreviations [11, p. 116f]:

*"In Russian it got the name SPID (Sindrom Priobretyonnoy Immunitetnoy Defitsitnosti)."* (10 February 2007). *"… and in Irish SEIF (Siondróm Easpa Imdhíonachta Faighte)"*. (6 May 2007).

But at the same time, processes of accommodation may be observed as well. A good example is the case of a controversial theory which was introduced into the article. According to this theory, research on substances for polio vaccination was originally responsible for transmitting the AIDS virus to humans. One sentence in the article: *"[The viruses] most likely got into humans via the hunting and eating of the original primate species"* was changed as follows to leave more room for other explanations: *"Possible ways for this virus to have originally infected humans include the hunting and eating of the original primate species"* (3 March 2006). Later, the entire approach of the explanation is modified: *"A more controversial theory known as the OPV AIDS hypothesis suggests that the AIDS epidemic was inadvertently started in the late 1950s in the Belgian Congo by Hilary Koprowski's research into a polio vaccine"* (28 November 2006). Reference is made, once more, to a theory that had already previously (20 February 2006) been described as follows:

*"One currently controversial possibility for the origin of HIV/AIDS was discussed in a 1992 Rolling Stone magazine article by freelance journalist Tom Curtis. He put forward the theory that AIDS was inadvertantly caused in the late 1950's in the Belgian Congo by Hilary Koprowski's research into a polio vaccine. Although subsequently retracted due to libel issues surrounding its claims, the Rolling Stone article encouraged another freelance journalist, Edward Hooper, to travel to Africa for 7 years of research into this subject. Hooper's research resulted in his publishing a 1999 book, The River, in which he alleged that an experimental oral polio vaccine prepared using chimpanzee kidney tissue was the route through which SIV mutated into HIV and started the human AIDS epidemic, some time between 1957 to 1959."*

What can be seen here is various stages of accommodation: A new idea is presented, then qualified to some extent, and finally integrated into the text in such a way that it supplements other theories.

Other examples of assimilation and accommodation processes in Wikipedia articles may be found in [11]. But we should not only be looking at modifications of the shared digital artifact, but also the corresponding changes in the minds of users (i.e. their cognitive systems). One method to examine this co-evolution of cognitive and social systems –

Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf

also using Wikipedia articles – is described in the following section.

## IV. Social Network Analysis of Wikipedia

A social network analysis [26] was able to demonstrate that changes of the content orientation of related Wikipedia articles were accompanied by similar changes in the orientation of those users who were involved [27]. The development of this co-evolution was illustrated by the article on "schizophrenia" in the German-language version of Wikipedia.

This topic is particularly suitable for initiating socio-cognitive conflicts and – as a consequence – equilibration efforts, because different approaches exist to explain what causes schizophrenia, and these are the subject of controversial discussion. One approach deals with social causes of schizophrenia, another one with biological and genetic aspects, and the so-called diathesis-stress model attempts to combine these two explanations. A (less accepted) psycho-analytical model of explanation exists as well.

In order to describe the co-evolution of cognitive and social systems, it was examined how the Wikipedia article on schizophrenia (and linked pages) changed in the course of time, and at the same time a closer look was taken on the development of the views of participating authors.

To analyze developments of the artifact, all pages that were linked to the schizophrenia article were rated by experts to which explanation model (social, biological/genetic or psycho-analytical) they belonged. These pages and the links between them were treated as the artifact network that was of interest here. In the visualization, the size of a page is an expression of the number of links that refer to that page. Visualization of the development of wiki pages and their links provides a representation of the development of the social system. To analyze authors of these wiki pages, attention is paid to the topics of their articles and modifications in the course of time.

As far as the digital artifact was concerned, a network analysis was able to show clear-cut effects. A comparison of, say, the artifact networks in 2007 and 2008 (as on 1 January respectively) revealed significant changes. In 2007 the "social" and "biological" clusters were still clearly separated (cf. Fig. 1).

The social cluster, as it appears on the top of Fig. 1, includes pages on "Paul Watzlawick", "Metakommunikation" (meta communication) and "Doppelbindungstheorie" (double-bind theory). The biological cluster, further down on the right, includes topics like "Amygdala", "Temporallappen" (temporal lobe) or "Nervensystem" (nervous system). The psycho-analytical cluster, bottom left in Fig. 1, is represented by pages on "Sigmund Freud", "Psychoanalyse" (psychoanalysis) or "Über-Ich" (super-ego).

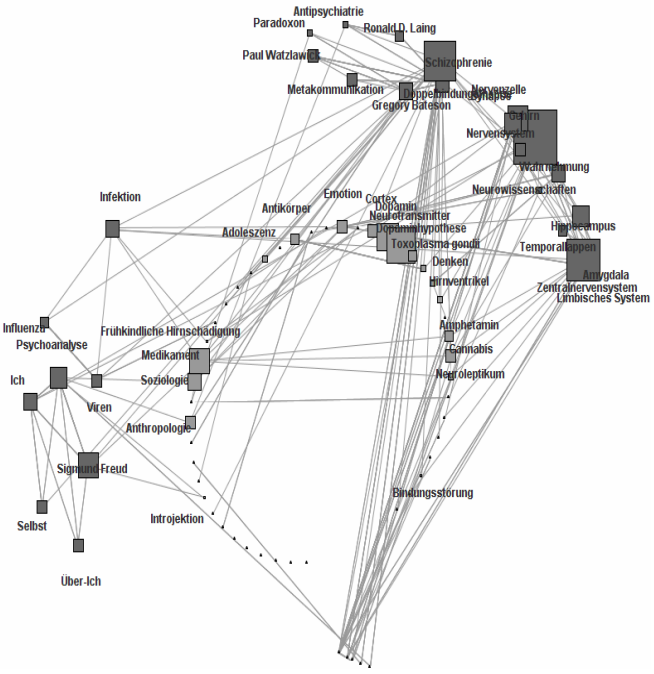



Fig. 1 Artifact network 2007

For the year 2008, however, the right hand side of the graphic consists of a large common cluster which contains both the articles on biological and social causes (cf. Fig. 2). The psycho-analytical cluster still stands on its own and is hardly linked to the rest.

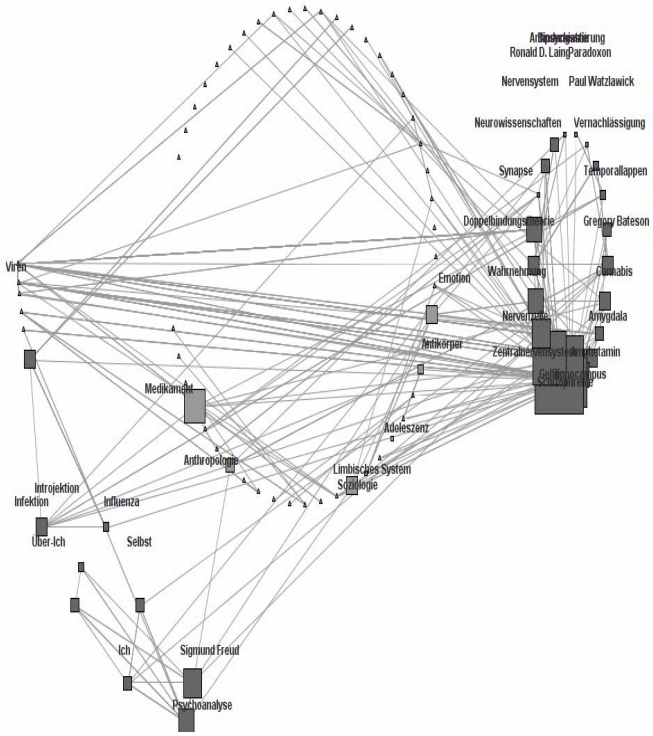



Fig. 2 Artifact network 2008

Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf

This is in line with a general trend in medical literature on schizophrenia. The diathesis-stress model, which assumes that there are both social and biological causes, is becoming the predominant explanation, whereas the psycho-analytical model tends to be regarded as an outsider position.

What is of particular interest in this context is the fact that a similar development as in the Wikipedia articles has also occurred with respect to those authors who contributed to these articles. It could be shown that various users who had been involved (originally) in articles on either social or biological aspects seemed to have adopted a more integrative point of view in the course of time [27]. No such development could, however, be observed with Wikipedia authors who had mainly been involved in psycho-analytical articles.

At this point, the question is how such co-evolution between cognitive and social systems is brought about. One factor which is regarded as an important starting point of processes of internalization and externalization and – in this way – of individual and collective learning was examined in a series of laboratory experiments, which will be presented in the following section.

## V. Experimental Studies

The driving force behind this co-evolution, in Cress and Kimmerle's model, is incongruity between the information contained in the digital artifact and the previous existing knowledge of a person who reads that information. This will lead to a cognitive conflict of that user to which this individual will react with equilibration.

The model uses an analogy to the work of [28] and [29]and assumes that there is a relationship between this incongruity and the extent of knowledge construction which may be visualized as an inverted U-shape: Low incongruity will not lead to perturbation of the cognitive balance, users will not experience a cognitive conflict, adaptation is not required. In the case of very high incongruity it will be difficult to link new information with existing knowledge; this will also prevent accommodation or assimilation. Medium incongruity is ideal to support the construction of new knowledge.

In order to allow empirical investigation of the Cress and Kimmerle model, an experimental paradigm was created. To operationalize the model, it was necessary to find a knowledge domain in which it is possible to distribute various knowledge items systematically between different people and the artifact. Again, schizophrenia and the question what causes this disease was selected as a suitable knowledge domain.

In order to create experimental material, extracts were made from textbooks on Clinical Psychology, presenting four arguments of about the same length on social explanations (S1-S4) of the disease and four arguments on biological/genetic explanations (G1-G4). Each of these eight arguments was complete in itself. This was the information base for a newly created digital artifact (wiki article on causes of schizophrenia) accompanied by what purported to be "newsletter articles" that were presented to participants, which they could then use as their own "previous knowledge" when working on the artifact.

Participants were first provided with information contained in the newsletters; each of these covered one item of information (the substance of these newsletters contained the same information as the corresponding wiki entries, but the newsletters had been enriched with additional information). Then, participants had access to the wiki, which contained a varying number of information items, depending on the experimental condition.

Participants were instructed to work on the wiki for 50 minutes. After that, the following dependent variables were measured:

- Internal assimilation: Factual knowledge about the eight arguments (knowledge test with 15 multiple choice items).
- Internal accommodation: Conceptual knowledge about the role played jointly by diathesis and stress in causing schizophrenia. This conceptual knowledge was operationalized by using an open question on causes of schizophrenia, measuring the extent to which arguments were combined in the sense of a diathesis-stress model.
- External assimilation: Number of words inserted into the digital artifact.
- External accommodation: Number of links between different arguments inserted into the digital artifact.

Three studies examined the hypothesis of an inverted U-shape relationship between information in the digital artifact and knowledge of individuals on the one hand and knowledge progress on the other, comparing processes of externalization and internalization.

Incongruity was operationalized in these studies as the difference between knowledge entities in the cognitive system and in the social system. There are two possible experimental implementations: keeping constant the amount of available information in the social system and manipulating the amount of knowledge in the cognitive system, or keeping constant the amount of knowledge available in the cognitive system and manipulating the amount of information in the social system. The former option was implemented in Studies #1 and #2, the latter in Study #3. Thus, in the sense of the model, Studies #1 and #2 primarily varied the options for internalization and Study #3 the option for externalization.

### *A. Study #1*

Study #1 examined three experimental conditions with different degrees of incongruity between information in the social system and knowledge in the cognitive systems, keeping information in the social system constant. In all three experimental conditions, all of the eight arguments were presented in the digital artifact. Variation in the experimental conditions concerned the extent of information that was available to participants as their own "prior knowledge" when working on the digital artifact (cf. Fig. 3).

In condition A (low incongruity), the participants knew all eight arguments, in condition C (high incongruity) they had no prior knowledge at all. In the "medium incongruity"

condition, the participants only knew the arguments of one position on causes of schizophrenia, i.e. either the four "social" arguments (condition B1) or the four "genetic" arguments (condition B2). Conditions B1 and B2 were equivalent, as far as incongruity is concerned, and can be regarded as variations of the same experimental condition, to balance any potential disproportion between genetic and social arguments.

In all conditions, participants had instant access to the wiki and were able to read it while reading the newsletter. 77 people participated in the experiment, distributed at random between the experimental conditions.




Fig. 3 Distribution of information provided in the artifact and availability to participants in three experimental conditions (B1 and B2 are logically equivalent) in Studies #1 and #2. G1 to G4 are arguments that describe genetic causes of schizophrenia, S1 to S4 arguments that describe social causes.

The varying extent of information that was available through the newsletters provided a variable for the extent of possible internalization in the experiment. The potential for externalization was kept at a constantly low level, as the artifact contained all the information. The theoretical considerations and corresponding research questions, as presented above, led to the following hypotheses:

People with little previous knowledge will find it difficult to externalize anything at all, so the lowest external assimilation was expected in condition C (Hypothesis 1).

As the groups differ in their prior knowledge, a corresponding difference of factual knowledge was expected, which could also serve as a treatment check. It was assumed, in other words, that differences of prior knowledge continue to exist because of the lack of opportunities to externalize one's own knowledge (Hypothesis 2).

The theoretical model predicted that the perceived conflict between information in the artifact and the participants' own prior knowledge was highest at medium incongruity. This should lead to more distinct conceptual knowledge, as a result of internal accommodation (Hypothesis 3) and more accommodation (Hypothesis 4) in the digital artifact.

Statistical analyses of the data revealed the following results:

Hypothesis 1 was confirmed: in condition C, considerably less external assimilation occurred than in the other conditions. Hypothesis 2 could only partly be confirmed: condition A had the highest degree of internal assimilation, but there was no difference between conditions B and C. Hypothesis 3 was confirmed: the highest degree of external accommodation occurred in condition B. Hypothesis 4, however, was not confirmed: there was no difference of internal accommodation in any condition [30].

This means that some of the expected effects could not be detected or were only of marginal significance. The results concerning Hypothesis 2 would indicate that the difference of knowledge of those users who participated in the study may have been too small. For that reason, a period of learning was introduced in the following study. Prior to working on the wiki, participants were asked to consider the content of the newsletter.

### *B. Study #2*

This experiment corresponded to Study #1, except that an additional learning phase preceded the rest in order to obtain more significant differences of the participants' prior knowledge. The learning phase differed depending on the number of newsletters which a participant had received.

In condition A, participants had 20 minutes to consider the newsletters, in condition B this was 10 minutes, and in condition C no such learning phase was necessary because participants were meant not to acquire any prior knowledge. 72 people participated in the experiment, distributed at random between the experimental conditions.

Statistical analyses of the data revealed the following results:

All hypotheses were confirmed, except that for Hypothesis 4 only marginally significant differences were detected between condition A and B.

In this study, the result that more learning time leads to more factual knowledge (Hypothesis 2) may be interpreted as a successful treatment check. What is relevant from the point of view of verifying theoretical predictions is the advantage of medium incongruity for processes of internal and external accommodation. This cannot be explained with the length of learning time, but only with incongruity between the information contained in the shared digital artifact and the participants' own knowledge.

### *C. Study #3*

The third experiment was, so to speak, a mirror-inverted replica of the previous two. While in all six experimental conditions of the previous studies information in the shared digital artifact was kept constant and participants differed in their prior knowledge, all participants in the third experiment had the same knowledge, and variation concerned the information contained in the artifact (cf. Fig. 4).

So the emphasis in the third experiment was on manipulating processes of externalization. 61 people participated in the study, distributed at random between the experimental conditions [31].

Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf

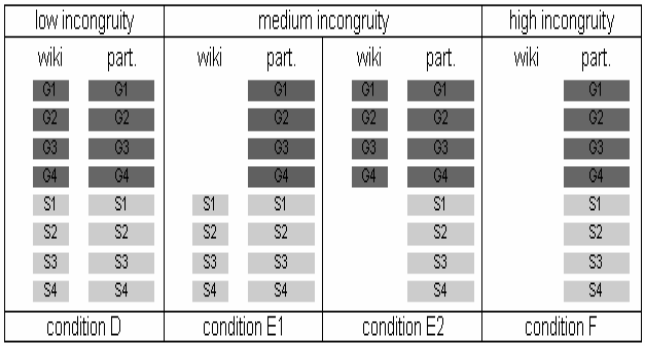



Fig. 4 Distribution of information provided in the artifact and availability to participants in three experimental conditions of Study #3 (E1 and E2 are logically equivalent). G1 to G4 are arguments that describe genetic causes of schizophrenia, S1 to S4 arguments that describe social causes.

It was expected that medium incongruity will be most conducive to all four processes: in the medium-incongruity condition more external assimilation (Hypothesis 1), more internal assimilation (Hypothesis 2), more external accommodation (Hypothesis 3), and more internal accommodation (Hypothesis 4) were expected.

Statistical analyses of the data revealed the following results:

All four predictions were confirmed by this study. Only as far as external assimilation was concerned, no difference was detected between conditions E and F [31].

## VI. Discussion

This article provides a survey of studies on the Cress and Kimmerle model of learning and knowledge building with shared digital artifacts. On the basis of Luhmann's systems theory the model describes processes of individual learning and collaborative knowledge building by defining shared digital artifacts and the respective communities behind these artifacts as "social systems", and by examining the interaction between such a social system and the cognitive systems of the individuals behind it.

The model refers to Piaget's theory of equilibration to describe cognitive development and applies the concept of assimilation and accommodation processes to the social system as well. The article highlighted assimilation and accomodation processes in a shared digital artifact by citing real examples from Wikipedia, the Online Encyclopedia. Co-evolution of cognitive systems and the social system was visualized by means of social network analysis. The model regards incongruity between the information contained in the digital artifact and the previous existing knowledge of a person as an important factor of that person's readiness to participate in knowledge-building processes and, in this way, to contribute to the development of cognitive and social systems.

Experimental studies have indeed confirmed that this incongruity is an influential factor of collaborative knowledge building. Future research in this field will concentrate on this type of experiments under laboratory conditions, in order to identify other relevant factors and gain a better insight into collaborative knowledge building with shared digital artifacts.

## References

[1] J. Kolbitsch and H. Maurer, "The transformation of the web: How emerging communities shape the information we consume," Journal of Universal Computer Science, vol. 12, pp. 187-213, 2006.
[2] T. O'Reilly, "What is the Web 2.0? Design patterns and business models for the next generation of software," Internet document, 2005, retrieved 03 July 2007 from: http://www.oreilly.de/artikel/web20.html.
[3] M. Sigala, "Integrating Web 2.0 in e-learning environments: A socio-technical approach," International Journal of Knowledge and Learning, vol. 3, pp. 628-648, 2007.
[4] D. Tapscott and A. D. Williams, Wikinomics: How mass collaboration changes everything. New York: Portfolio, 2006.
[5] S. Johnson, Emergence: The connected lives of ants, brains, cities, and software. New York: Scribner, 2002
[6] O. Arazy, W. Morgan and R. Patterson, "Wisdom of the crowds: Decentralized knowledge construction in Wikipedia, " presented at the 16th Annual Workshop on Information Technologies & Systems (WITS), Milwaukee, WI, 2006.
[7] J. Surowiecki, The wisdom of crowds. New York: Anchor Books, 2005.
[8] N. Luhmann, Social Systems. Stanford: Stanford University Press, 1995.
[9] J. Piaget, "Piaget's theory," in Carmichael's manual of child psychology, P. H. Mussen, Ed. New York: Wiley, 1970, pp. 703-732.
[10] U. Cress and J. Kimmerle, "A theoretical framework of collaborative knowledge building with wikis: A systemic and cognitive perspective," in Proc. 7th Computer Supported Collaborative Learning Conference, New Brunswick, NJ, 2007, pp. 153-161.
[11] U. Cress and J. Kimmerle, "A systemic and cognitive view on collaborative knowledge building with wikis," International Journal of Computer-Supported Collaborative Learning, vol. 3, pp. 105-122, 2008.
[12] N. Luhmann, "System as difference," Organization, vol. 13, pp. 37-57, 2006.
[13] N. Luhmann, Soziale Systeme. Grundriss einer allgemeinen Theorie. Frankfurt am Main: Suhrkamp, 1984.
[14] N. Luhmann, "The autopoiesis of social systems," in Sociocybernetic paradoxes, F. Geyer and J. Van der Zouwen, Eds. London: Sage, 1986, pp. 172-192.
[15] F. J. Varela, H. R. Maturana, and R. Uribe, "Autopoiesis: The organization of living systems, its characterization and a model," Biosystems, vol. 5, pp. 187–196, 1974.
[16] N. Luhmann, Essays on self-reference. New York and Oxford: Columbia University Press, 1990.
[17] N. Luhmann, "Operational closure and structural coupling: The differentiation of the legal system," Cardozo Law Review, vol. 13, pp. 1419-1441, 1992.
[18] F. Kofman and P. Senge, „Communities of commitment: The heart of learning organizations," Organizational Dynamics, vol. 22, pp. 5-23, 1993.
[19] J. Piaget, The development of thought: Equilibration of cognitive structures. New York: The Viking Press, 1977.
[20] J. Piaget, "Problems of equilibration," in Topics in cognitive development, vol. 1, M. H. Appel and L. S. Goldberg, Eds. New York: Plenum, 1977, pp. 3-14.
[21] U. Cress, J. Kimmerle, C. Held, and F. W. Hesse, "Social software and knowledge building: Supporting co-evolution of individual and collective knowledge," in Designs for learning environments of the future: International learning sciences theory and research perspectives, M. J. Jacobson, Ed. Berlin: Springer, to be published.
[22] E. Tulving, "How many memory systems are there?," American Psychologist, vol. 40, pp. 385-398, 1985.
[23] J. R. Hayes and L. S. Flower, "Identifying the organization of writing processes," in Cognitive Processes in writing, L. W. Gregg and E. R. Steinberg, Eds. Hillsdale, NJ: Erlbaum, 1980, pp. 3-30.

Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf

[24] P. Tynjälä, L. Mason, and K. Lonka, K., Eds. Writing as a learning tool: Integrating theory and practice. Studies in writing. Dordrecht: Kluwer Academic Publishers, 2001.
[25] J. H. Holland, Emergence from chaos to order. Redwood City: Addison-Wesley, 1998.
[26] S. Wassermann and K. Faust, Social Network Analysis: Methods and Application. Cambridge: Cambridge University Press, 1994.
[27] A. Harrer, J. Moskaliuk, J. Kimmerle, and U. Cress, "Visualizing wiki-supported knowledge building: Co-evolution of individual and collective knowledge," in Proc. WikiSym'08 – International Symposium on Wikis, New York: ACM Press, 2008, to be published.
[28] D. E. Berlyne, Conflict, arousal, and curiosity. New York: McGraw-Hill, 1960.
[29] J. McV. Hunt, "Intrinsic motivation and its role in psychological development," in Nebraska symposium of motivation, D. Levine, Ed. Lincoln, NE: University of Nebraska Press, 1965, pp. 189-282.
[30] J. Kimmerle, J. Moskaliuk, and U. Cress, "Effects of incongruity between knowledge and information on learning and knowledge building," Learning & Instruction, submitted for publication.
[31] J. Moskaliuk, J. Kimmerle and U. Cress, "Learning and knowledge building with wikis: The impact of incongruity between people's knowledge and a wiki's information," in Proc. International Conference for the Learning Sciences, vol. 2, Utrecht, The Netherlands: International Society of the Learning Sciences, 2008, pp. 99-106.

Open Science Index, Psychological and Behavioral Sciences Vol:2, No:10, 2008 publications.waset.org/7501/pdf