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A case study analysis of a constructionist knowledge building community with activity theory

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Abstract

This article investigates how activity theory can help research a constructionist community. We present a constructionist activity model called CONstructionism Through ACTivity Theory (CONTACT) model and explain how it can be used to analyse the constructionist activity in knowledge building communities. We then illustrate the model through its application to analysing the Wiki-supported community associated with a computer game. Our analysis focuses mainly on two perspectives: individual and collective actions, as well as individual and collective mediations. Experiences and challenges from the analysis are reported to demonstrate how CONTACT is helpful in analysing such communities.

Introduction

"Paper has an even more potent role than as a storehouse of knowledge. It achieves remarkable power when it is a blank sheet, inviting student creativity . . . It is taking decades for educators to recognise that the most potent use of videotapes happens when teachers offer blank ones to students." (Shneiderman, 2002)

For decades, scholars have been relying on cognitivist or constructivist approaches for researching technology-aided learning and teaching. Myriad models of analysis, methods and frameworks have been developed to help design and evaluate educational technologies (Lebow, 1993; Oliver, 2000). Although they are helpful, the advancement of learning theories from behaviourism to social constructionism; and technologies from standalone to networked computers has called for the development of more comprehensive theoretical or methodological frameworks. This has shifted the focus of instructional design to constructional design (Resnick et al, 1998). Constructional design advocates that learners

should be treated more like experts constructing new knowledge than novices receiving existing knowledge. Knowledge has become a more personal property than a general entity; it is also a more concrete artefact than an abstract concept. Further, knowledge is considered to be stored not only within a person's head but also situated around a social cultural context (Lave and Wenger, 1991).

Some researchers have started shifting the focus to the social cultural perspective (Barab et al, 2002) of learning. This is an important paradigm shift as constructionists base their arguments on individual development which is enhanced by shared constructive activity in the social cultural setting (Shaw, 1995).

It is also crucial to realise that the advent of new media such as computer games not only changes how people perceive and understand new forms of multi-media messages but also how people use media to express themselves. Educators should come to understand that presenting knowledge in a media-rich, social-oriented technology is not the most desirable way of teaching and learning. What is more important is that students should use these media for expressing their creativity (Shneiderman, 2002).

We believe that constructionism as defined by Papert (Papert and Harel, 1991) provides powerful theoretical tools to explain learning in a social technological context. However, constructionism remains largely a theoretical model, and without operationalisation of its theoretical constructs, it may be hard to use it directly to analyse such learning communities. Therefore, in this article we propose using activity theory (Engeström 2001) to operationalise constructionism (see Sections 2.1 and 2.3 for detailed descriptions of constructionism and activity theory).

Through this, we aim to develop a unified framework that incorporates models of knowledge building, perspectives and artefacts, and is grounded in empirical analysis of collaborative interactions. Such a framework can guide the design of computer-based artefacts as support for constructionist learning systems with unified conceptualisations and theoretical constructs.

Specifically, the aims of this study are:

- (1) To develop a model for analysing constructionist learning based on Engeström's (2001) activity theory triangle and Papert's (Papert and Harel, 1991) constructionism
- (2) To apply the model to analyse a Wiki-supported knowledge-building game community in order to give insights on how it evolves and develops.

This article is structured as follows: Section 2 reviews the theoretical background which includes constructionist theory of learning, computer-supported collaborative learning (CSCL) and activity theory. Section 3 presents the CONstructionism Through ACTivity Theory (CONTACT) model which is an adaptation of Engeström's (2001) triangle activity system by incorporating the concept of constructionism. Section 4 is the major part of this article and it presents the example application of the model. In this section, Wiki technologies are introduced and their potential to support knowledge building communities (KBCs) is illustrated. Then, the data collection and data analysis method is explained. The findings of the study as well the discussion of the results and the implications are also presented in detail. Section 5 discusses the future direction in which we are heading and Section 6 concludes the article.

2. Theoretical background

2.1. Constructivism and constructionism

Although some educators still expound the behaviourist method of knowledge transfer from experts to novices, psychologists such as Piaget (Piaget, 1929), Vygotsky (Vygotsky, 1930) and others proclaim that learning is less about filling learners' head with abstracted facts, than it is about constructing reality internally through collaboration.

Constructivism as initiated by Piaget (1929) has had a significant epistemological and pedagogical impact. According to this theory, learners do not receive knowledge from the external world. Instead they interact physically and socially with the environment and constantly construct and update their knowledge internally. In other words, constructivists put learners into the experts' shoes, contending that everyone should construct their own versions of reality by extracting abstract and formal knowledge from the context.

Our work is based on Papert's view of constructivism, which he terms constructionism. Papert's (Papert and Harel, 1991) constructionism goes beyond what is constructed inside learners' heads. Being Piaget's student, Papert's constructionism is largely influenced by constructivist theory. But, although constructionism embraces and builds upon Piaget's constructivism, Papert eventually came to see some drawbacks in Piaget's stage of cognitive development theory (Piaget and Inhelder, 1969). He disagrees with Piaget's stage theory in which adults abandon concrete thinking in favour of formal thinking. To Papert, concrete thinking and formal thinking are two different cognitive styles which persist in adulthood. This epistemology pluralism states that people do not give up concrete thinking in order to move forward to a higher level of thinking. Both are equally important in human learning.

In terms of pedagogy, Papert claims that even for adults, learning remains essentially bound to context, in which knowledge is shaped by the use of external supports. Papert's approach helps us understand how learning is actualised when individual learners construct their own favourite artefacts or object-to-think- with (Papert, 1980). In his own words, Papert defines constructionism by stating that:

"We understand 'constructioNism' as including, but going beyond, what Piaget would call 'constructiVism.' The word with the V expresses the theory that knowledge is built by the learner, not supplied by the teacher. The word with the N expresses the further idea that this happens especially felicitously when the learner is engaged in the construction of something external or at least shareable . . . a sandcastle, a machine, a computer program, a book. This leads us to a model using a cycle of internalisation of what is outside, then externalisation of what is inside and so on." (Papert and Harel, 1991)

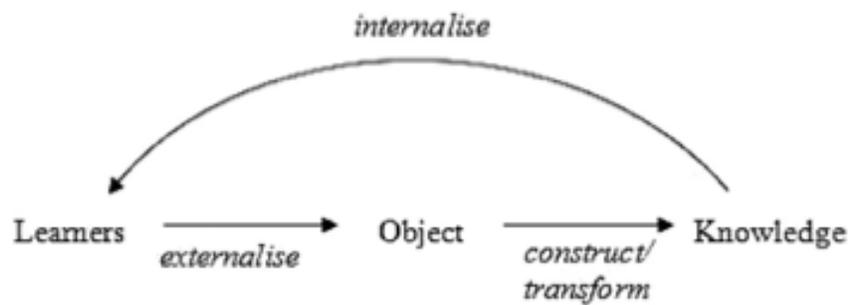


Figure 1: The fundamental concept of constructionism.

We attempt to visualise this concept in Figure 1 in order to illustrate the fundamental idea of constructionist learning. Learning is thus understood as a cyclical process of constructions in which the learners externalise their initial state of knowledge through building an object which helps them update their old knowledge as well as interpret and construct new knowledge. As knowledge is being constructed or transformed through the manipulation of objects, this new knowledge is internalised by the learner and the cycle continues.

Papert's theory bears a lot of similarities to Vygotsky's (1930) social cultural theory which stresses socio-cultural aspects in learning, claiming that learning is mediated by cultural tools in which socio-cultural knowledge amasses. Learners do not interact with the environment directly; instead the interaction is socially mediated with artefacts, be it signs (language) or tools. Cognitive development occurs at two levels: knowledge is constructed socially (inter-psychological level) before it is internalised into each individual (intra-psychological level).

Constructionism, however, goes beyond social cultural theorists' claims that learning is mediated by the cultural semiotic system. Constructionism suggests that learning involves the effort to create external symbols to move formal symbols constructed internally and locate them in the environment. In other words, Papert's constructionists emphasise that learning is more effective when learners are engaged in designing or constructing something tangible. For example, Papert himself has spent more than two decades developing the LOGO programming language that enables students to grasp complicated mathematical concepts by creating software artefacts (Papert, 1980).

2.2. Computer-supported collaborative learning (CSCL)

The advancement of learning theories towards social paradigms has resulted in the emergence of a new area of study in e-learning, known as CSCL that emphasises the collaborative aspects of learning as well as the social interaction among learners in knowledge construction. It is a shift in the use of technologies from treating computers as a personal tutor to a communication medium that promotes authentic group learning.

Although it is clear that the design, analysis, implementation and evaluation of CSCL is largely informed by social cultural theories (e.g. social constructivism), Koschmann (1996) notes that one of the problems with CSCL is the lack of connection between constructivist views of learning and the study of learning as social practice. He attempts to resolve this question by concentrating on providing an adequate description of learning as a process of meaning-making rather than a focus on learning outcomes (Koschmann, 2001).

Learning is thus treated as the process of meaning-making through social interaction between learners and their peers. Vygotsky's (1930) conception that all higher mental processes take place between people before they are internalised is congruent with constructivist views of learning. The social aspect of learning is understood as a process of social negotiation and joint knowledge construction. In the context of collaborative learning, negotiation is viewed as a process by which learners attempt to attain agreement on aspects of the learning task and on certain aspects of the interaction itself (Dillenbourg et al. 1996).

This is in line with Duffy's claim that learning is inherently a social, dialogical process (Duffy et al, 1993). That is, given a problem or task, people naturally seek out opinions and ideas from others. Technologies can support this conversational process by connecting learners across the world. When learners become part of KBCs, they learn that there are multiple ways of viewing the world and multiple solutions to life's problems. As such, CSCL is always mentioned in tandem with KBC which is a group of learners committed to

advancing the group's knowledge of some shared problems through collaboration (Hewitt, 2002).

Therefore, CSCL is thought to be more ambitious than previous approaches to e-learning, making it more difficult to evaluate the effectiveness and efficiency of such learning activities. Significant research work needs to be carried out to provide systematic evaluation, theoretical framework development and the new CSCL system implementation.

For many years, theories of collaborative learning tended to focus on how individuals function in a group. In CSCL, however, the focus has shifted so that the group itself has become the unit of analysis (Dillenbourg et al. 1996). Hence, some of the focuses of research would be looking at CSCL include:

- Collaborative knowledge building
- Group and personal perspectives
- Mediation by artefacts
- Micro-analysis of conversation provides a rich, multi-dimensional starting point for conceptualising and studying CSCL (Stahl, 2002).

The notion of collaborative knowledge building defines a useful paradigm for conceptualising learning as social practice in which shared knowledge is constructed can be analysed as the result of inter-related group and personal perspectives. Thus, what is needed is a theoretical framework incorporating models of constructionist knowledge building to analyse such learning communities.

2.3. Activity theory

Although Papert's theory provides a solid framework for understanding children's and even adults' ways of learning by designing, it does not offer a systematic framework for analysing the construction activities within a learning community. The most important analysis includes the collective learning within a community as well as the development of an individual. We are also interested in finding out how tools such as computers help learners construct artefacts and knowledge. Hence, we would like to draw from the Vygotskian naturalist approach which emphasises human activity systems. Vygotsky (1930) formulated a theoretical concept which is very different from the prevailing understanding of psychology dominated by behaviourism at that time. This new orientation was a model of tool-mediation and object-orientedness. He proposes the classic triangle model to demonstrate the idea of mediation.

In Figure 2, the subject is the individual engaged in the mediated action, the mediating artefact or tool could include physical artefacts and/or prior knowledge of the subject. The

object is the objective of the activity. Figure 2 shows explicitly that the relationship between the subject and the object is no longer straightforward as in Figure 1. Instead it is mediated by external and internal tools. For example, when building a website, the subject is working towards an objective (e.g. to add a table to the webpage) using not only the computer (external tools) but also her internal understanding of how websites and computers work (internal tools).

Leont'ev (1978) extends this notion of activity to differentiate between an individual action and a collective activity by proposing a hierarchy of activity (Table 1). Collective activity is connected to the object of the whole community, of which each individual subject is often not consciously aware. An individual action is connected to a conscious goal. Below the collective activity and individual action there is the level of operations that are dependent on the conditions in which the action is performed. Thus, an activity system can be analysed at three levels: the activity level which is oriented towards the object/ objective and carried out by the whole community; the action level which is directed at the individual goal, as well as the operation level which is elicited by conditions and is performed unconsciously.

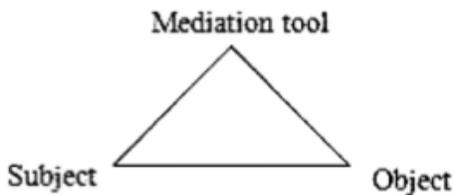


Figure 2: Vygotsky's mediation

This hierarchy is crucial in explaining the learning process in an activity system. We would like to illustrate an example of this hierarchy in learning a foreign language (refer again to Table 1). The overall objective is to be able to engage in a meaningful conversation. In the beginning, the learner has to work on the grammar and the choice of words at a conscious level. When the learner has reached a higher proficiency level, these actions are transformed into operations. The learner no longer needs to select appropriate words and check grammar rules deliberately as these have been learned thoroughly and are now operating unconsciously. The consciousness of the learner is now focused on expressing himself properly depending on the objective of the conversation. Grammatical rules become invisible to the learner and he is only selecting appropriate goals to be achieved. Therefore, it can be inferred that activity theory treats learning as the shift from the higher level to the lower level in the hierarchy (e.g. from actions to operations). Nevertheless, upon encountering new

mapping between activity theory and constructionism. Due to its open-endedness, we find it difficult to use the traditional model of activity proposed by Engeström for our purpose to study a constructionist learning community.

First and most apparently, the hierarchy of activity, which implies the learning process, is not incorporated into the traditional model. Therefore, we attempt to solve it by explaining the relationship in subject-tool-object and subject-community-object with different levels of activity expanded from Leont'ev's model (Table 1), including individual and collective actions and operations.

By adopting this concept, we need to present the dynamics of each element in the activity system. As the actions shift to operations, the element in the activity system is changed too. The static representation of activity theory represents only a snapshot of a particular time, thus making it hard to analyse the activity across time. Although the concept of transformation is a significant part of activity theory, it does not provide a standard way to operationalise this transformation of the activity: especially the transformation of each component and the relationship.

Third, whilst attempting to produce an activity system for the learning community, it is important that the process of modelling an activity system requires basic understanding or prior knowledge about the situation being examined. The activity triangle model does not provide this kind of insight as it does not capture historical data prior to the current activity system. Fourth, the heart of the constructionist learning concept, internalisation and externalisation, are not visualised. The construction of knowledge within an individual and within the community is not explicated explicitly.

3. The CONTACT model

In this section, we present an adaptation of Engeström's triangle activity system that can enable us to analyse constructionist learning. Although Engeström (2001) proposes expansive learning (that learning is the development through resolving contradictions for collective development of activity) as the learning theory for activity theory, this proposition is not directly reflected in his triangle model. We try to articulate, within a modified triangle model, the learning process through the hierarchy of activity in order to analyse constructionist learning. Figure 4 shows a graphical representation of the activity system from the perspective of constructionist learning. We call it the CONTACT model. We attempt to incorporate the idea of constructionist learning into activity theory, in order to produce a unified model to explain constructionist CSCL.

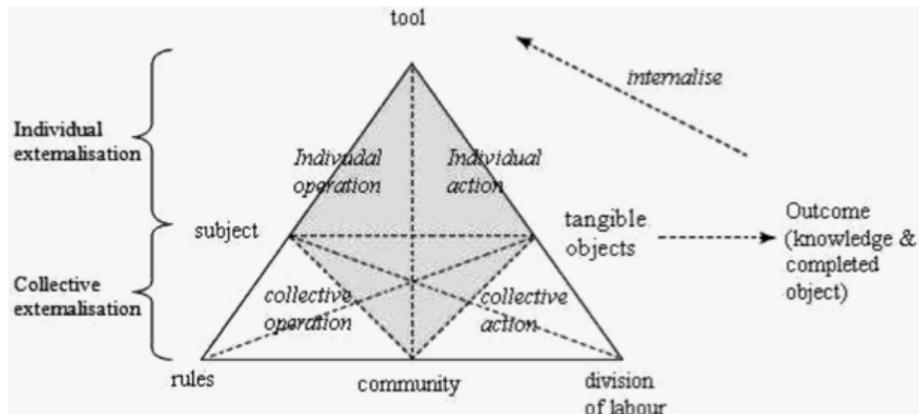


Figure 4: The CONTACT Model

The most important adaptation is that we explicate the externalisation process through mediation. As the process of externalisation through tangible objects is central to constructionist learning, there is a need to explicate this process within the diagram. This is marked by the shaded area and the named relationship of subject-tool-object and subject-community-object. We also add an extra arrow that links the outcome to the tool in order to show the internalisation process. Then, we delimit the meaning of object and refer to it as the tangible object in order to be in line with the theory of constructionism.

Like the original triangle model, CONTACT is made up of seven components. The subject in this case represents the learner, while the tool is usually computational tools which include hardware and software. Like Engeström's model, it also refers to initial knowledge of the learner. The community consists of learners of different backgrounds working together to construct the object. The object is the tangible artefact which is being worked on by the learners. It will then be transformed into the outcome which in this context is the knowledge and the complete sharable object. Last but not least, the interaction between the community and the learner is mediated by rules and the DOL.

Although an object in a general activity system could be conceptual or abstract, constructionist activities emphasise tangible objects which are created by the learners to express their internal ideas. Mediated by tools, usually computational ones, learners are able to project their initial understanding of a concept and transform it into knowledge which is situated in both external objects and the learner's mind. The concept of object should not be confused with the tool. Objects are something incomplete that are currently being constructed by the learner. In a constructionist context, they are tangible artefacts. Tools are something which are used by the learner to construct the object and they can be physical (such as pencils) or conceptual (such as grammar rules). It should also be noted that a completed object (the outcome) can eventually become a tool in the next generation of an activity

system. This process is known as internalisation. Note that unlike Figure 1, where internalisation is directed to the learner, this process is directed to the tool in CONTACT, as activity theory treats tools as extensions to the subject.

We also attempt to visualise the concept of externalisation through the hierarchy of activity by defining the relationship between subject, tool, community and object (the shaded area in Figure 4). Based on Leont'ev, the subject operates the tool unconsciously to act on the object at a conscious level. In addition to this, we propose that actions and operations also take place at the collective level. The subject collectively operates with the community to collectively act on the object.

One example of such collective actions and collective operations in the context of constructionism is agreement and negotiation: an agreement on the developing artefact takes place through the process of negotiation. Thus, the subject agrees with the community to negotiate on the object. We also suggest that individual operations and agreements happen unconsciously. The difference between the two concepts is that individual operations are taken individually whereas agreements are taken collectively. In other words, an operation is conditioned towards individual unconscious, while an agreement is conditioned towards what Carl Jung (as cited in (Boeree, 1997)) refers to as collective unconscious. Table 2 presents our proposed hierarchy of collective actions and collective operations.

Mediated by the tool and the community, the learner externalises her initial stage of knowledge through object construction. The individual externalisation (mediated by the tool) can be broken down into actions and operations. Actions are directed towards a personal goal and are carried out with careful deliberation. For example, in order to write a book with a word processing program, the author (the subject) needs to construct sentences carefully in order to express herself correctly. On the other hand, operations are autonomous responses to a condition and are carried out unconsciously without deliberation. For example, for a regular computer user, moving the mouse cursor around and clicking the cross button to close a software program are operations. Sometimes, an action might become an operation if it is practised many times. We call this a shift of operations and actions and we demonstrate this through the example of a book writing activity (Figure 5).

In a book writing activity, the author (an expert word processor user) will operate (e.g. typing) the word processor at the unconscious level and consciously act on the book (to select appropriate words, construct meaningful sentences and paragraphs) she is writing. At a certain point, the author encounters a new condition with the word processor which she is not familiar with: say to insert a table into the book. Under this new condition, a breakdown is

said to have happened. The conscious effort of the author is no longer placed on the book itself but instead is now placed on the word processor (e.g. to achieve the action: insert tables, the author performs the operation: read help files). Once the author has thoroughly learned about the table insert, she can again act on the book consciously and development is said to have happened.

Unit of analysis	Stimulus	Subject
Individual action	Goal	Individual conscious
Collective action		Collective conscious
Individual operation	Conditions	Individual unconscious
Collective operation		Collective unconscious

Table 2: A hierarchy of collective actions and operations

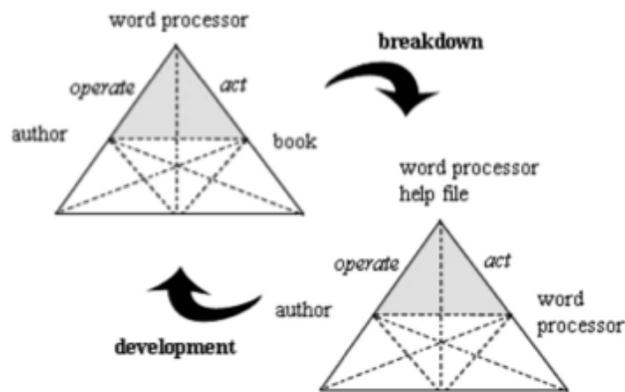


Figure 5: The transformation of individual action-operation

In a similar way, the collective externalisation (mediated by the community, rules and DOL) can be broken down into negotiations and agreements. Negotiations are brought about by the conflict in a community and are carried out consciously with careful deliberation. For example, in order to write a book collaboratively, every author needs to negotiate and achieve an agreement about the format of each chapter. For that reason, we say that agreements are driven towards a set of established rules among a community. Once an agreement is achieved, each member in the community no longer needs to deliberately negotiate about it. Thus it can be said that final agreements are reached unconsciously without any deliberation. For example, once the format of each chapter is decided, each author will refer to the ‘formatting rules’ without having to negotiate again.

Figure 6 shows the shift of agreement (collective operation) and negotiation (collective action). In a collaborative book writing activity, the editor will agree with other authors and negotiate the contents of the book (e.g. for them to collaboratively achieve the action: write the book, they will collaboratively perform the operation: agree topics). At a certain point, the author encounters a new condition which has yet to be agreed by the community of authors: say an author raises an issue of text formatting. A breakdown is said to have happened as the conscious effort of the authors is now placed on the formatting rules, not the book itself (e.g. now for them to collaboratively achieve the action: decide the text format, they will have to collaboratively perform the operation: discuss with the community). Once the authors have agreed the text format, the rules are updated and they can again act on the book consciously and the development is said to have happened (operation: agree with the topic and text format, action: negotiate the contents and collectively write the book).

It is also important to note that although we divide the triangle into two levels, i.e. individual and collective externalisation, these two levels are in fact inter-related. The interaction between two learners might result in the development of each individual tool. For example, two book authors might discuss the use of the word processor and through this eventually develop their individual skill on using the word processor.

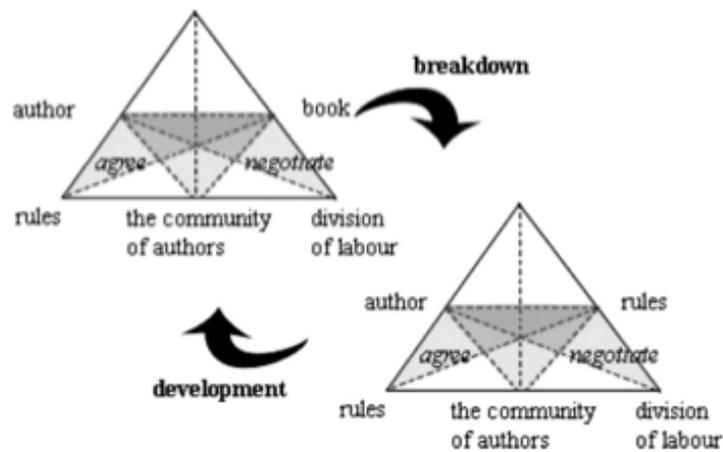


Figure 6: The transformation of collective action-operation

4. An application of CONTACT to a Wiki community

In this section, we demonstrate how the CONTACT model can be applied to analyse a Wiki-supported knowledge building game community. Before this, it is important to acquaint the readers with Wiki technologies.

4.1. Wiki technologies

The 'Wiki', named from the Hawaiian word 'quick', is a new technology that allows everyone to be the author. It is a freely expandable collection of hypertexts which can be easily edited by any user with knowledge of a very simple mark-up language. It does not require any specialised tools; all you need is a form-capable web browser client. This simple editing method gives the freedom to everyone reading the page to amend or correct it. Wikis explicitly support collaboration as they decentralise the effort of creating a website from the hands of the few and distribute it to a huge community of internet users. In a Wiki environment, users are not only editing, they are also encouraged to create their own content and their own pages. A link to existing pages can be made easily, and a new page can be created by making a new link. Thus, apart from contents, the users also co-design the structure of a Wiki site.

The goal of Wiki sites is to become a shared repository of knowledge, with the knowledge base growing over time. Unlike chatrooms, Wiki content is expected to have some degree of seriousness and permanence. In a Wiki, it is the users who create the content in collaboration and over time. Like Weblogs, Wikis have been around for some time and are popular among the technology community. However, Weblogs can be highly personal while Wikis are intensely collaborative.

Recently there has been an increasing interest in using Wikis for learning (Jones, 2003; Wang, et al. 2005). Although any knowledge building application that demands the absolute and immutable integrity of the content is not really suitable for a Wiki, it is useful in situations where communities of people are developing shared ideas, values or resources. A teacher of biology, for example, could start a Wiki site by posting some material creating a tentative structure for the subject, and uploading some media files. When students visit, they could expand the contents by modifying them, by posting more material, or by making links to new pages, thus enriching the learning resources. Through shared construction cycles, the students feel closer to the learning system as they contribute to its development instead of being passively presented with the information.

A project has already been undertaken to re-build a web-based learning site for spectroscopy using Wiki technologies with the goal of making the resource more relevant and content-rich, so as to attract authors from different backgrounds to provide content in multiple languages to support international users (Mader, 2004). Perhaps the most famous educational Wiki in existence is Wikipedia (Wikipedia, 2005). It is a free-content encyclopaedia operated by the

Wikimedia foundation that anyone can edit. It is the result of a vast collaboration and currently contains over a million entries in multiple languages.

The Wikimedia foundation has also created the Wikibook project which is a collaborative book writing implementation aimed at building communities that contribute to the development of hypertext books available free of charge to the public. The Wikipedia and Wikibook projects show that the Wiki concept might work, and that groups of people can collaboratively create shared knowledge artefacts.

4.2. Method

The development of the CONTACT model was based on the grounded theory method, in which the theoretical model emerges through the iterative cycle of qualitative data analysis.

We started our analysis with the original AT triangle model as proposed by Engeström, and throughout the research, we constantly revised and modified it as new concepts and relations emerged from the data analysis (Glaser and Strauss, 1967).

For each of the Wiki pages, we started by browsing and reading the information to get a general overview/ impression of what kinds of information was created. After that, the contents were read carefully to extract important information that would reveal constructionist learning. The goal was to find out all possible processes observed in the Wiki community. Emphasis was put on issues that occurred frequently or that were deemed of fundamental importance.

We categorised these processes according to the traditional activity theory triangle model. Processes not visualised in the original triangle were added to the diagram as we revised and developed CONTACT. For instance, the process of collective externalisation was observed frequently in the community in various contexts, in which a number of users constantly modified a piece of text until an agreement had arrived. This important process was then added to the diagram. Please refer to Table 2 for new externalisation processes identified through the analysis.

As we expanded and modified the CONTACT model, we found that the model was increasingly able to explain more activities/process in the Wiki community. We went through a series of iterative cycles of data analysis for this study and stopped only when theoretical saturation has been reached, e.g. when the model can explain all the processes we observed in the community. The validation of the final model was achieved through additional cycles of analysis which demonstrated that the examination of new data revealed no new information regarding the theoretical constructs and their relations. Therefore, our proposed model is both

data driven in its construction and validation and can be inductively generalised to the population represented by the selected sample (Glaser and Strauss, 1967; Strauss and Corbin, 1990).

Then, by using the CONTACT model, we examine how the community of a Wikibook evolves and what are the characteristics that lead to the growth of such a KBC. More specifically, in order to demonstrate the usefulness of the CONTACT model presented in the previous sections, we apply it to describe actual data collected from a Wikibook of a computer game community.

4.2.1. The Wikibook

We examined the ‘Grand Theft Auto: San Andreas’ game Wikibook that provides game-related information to the player. ‘Grand Theft Auto: San Andreas’ Wikibook (Figure 7) was selected for this study because of our familiarity with this computer game and a preliminary scrutiny on the site revealed that the development of this community is rather active, thus it provided sufficient data for analysis.

Each page in the Wikibook has its own history page that documents its evolution by recording all the changes/edits made by every participant. It contains the following information: who made the change, what changes were made, when they were made and an option to let the participant explain why a change was made. Figure 8 shows the history page for the main page of this Wikibook. It displays a list of all the versions of the page from its creation to its current version. To identify the differences between two versions of the page, the user must select and compare them from the history list (Figure 9).

4.2.2. Data collection method

We collected data from 11 pages of the Wikibook. These pages were the work of 65 participants (17 registered, 48 unregistered) who contributed a total of 421 edits. The collected data spanned across 226 days. We also collected the discussion among the participants on the discussion page (if any). Participants can start a new discussion for each page they are working on by clicking the discussion tab (Figure 8). Apart from these, we also examined the title and description of each edit (Figure 8). Some participants described the changes/ edits they made, and why a change was made; such information gave some insights into the goal of their actions, thus helping us to carry out the categorisation. Meta-book pages which provide information regarding the Wikibook project were examined as well. Empirical data presented in this study are also comprised of field notes kept during the study. These

field notes consisted of personal reflections on the method of analysing the data with activity theory.

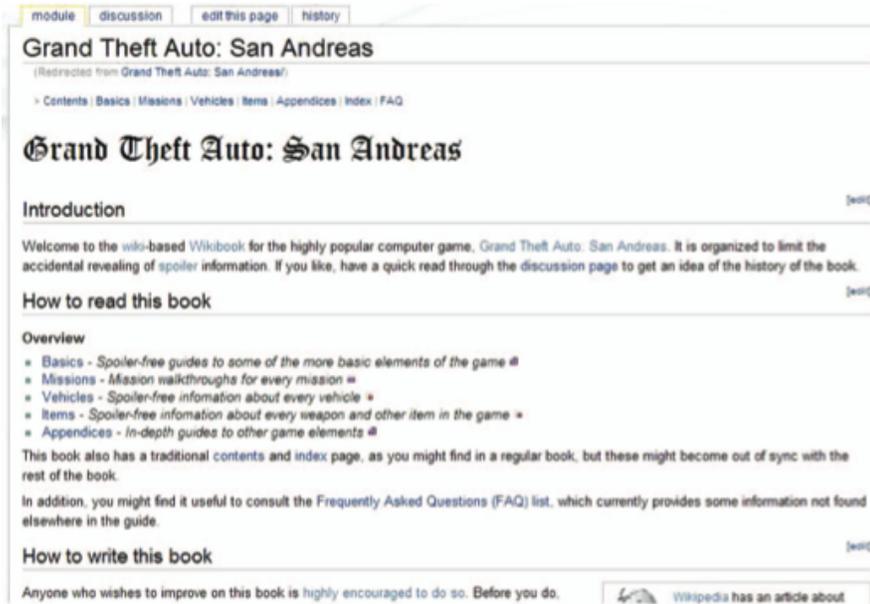


Figure 7: The main page of the 'Grand Theft Auto: San Andreas' Wikibook (Grand Theft Auto: San Andreas 2005)

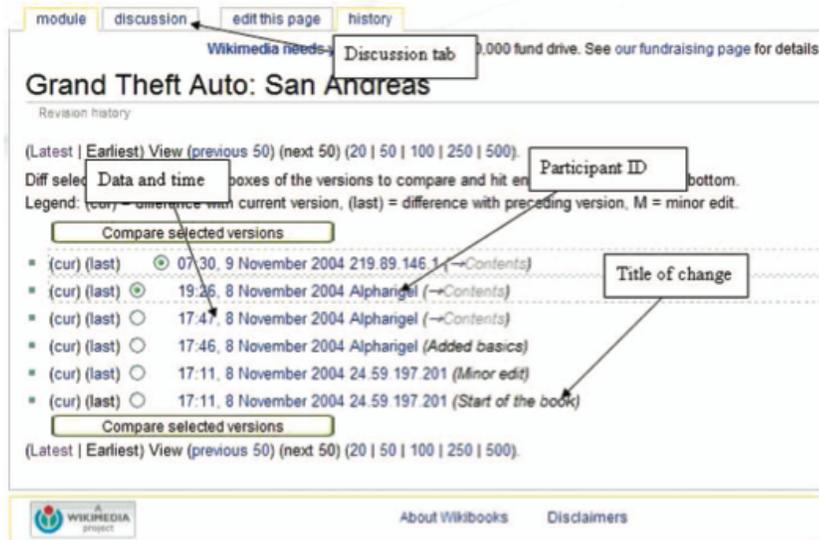


Figure 8: The history page

4.2.3. Analytical method

For each of the pages, we recorded and examined every single change/edit as recorded from its history page and then categorised the change. For example: was it a change of game contents or was it a deletion or a correction of grammar? The categorisation for each change of the page was recorded and the same process was repeated for other pages until no new category could be found. Using card sorting technique, we group these categories together until high-level categories emerged.

In order to validate the category, we ran a focus group with three PhD students who have experiences in similar qualitative research. We aimed to reach a point of convergence among the participants through the focus group in order to come up with a consistent category set. This exercise was carried out in a focus group room which was equipped with an interactive whiteboard. We started by explaining the aim of the research and a brief of the study. Then, the category scheme was described, supported by examples. Each participant was required to apply the scheme individually to check if it was able to explain the actions in a new Wiki page. After that, each individual result was discussed in a group setting until an agreement had been reached. In principle, all participants agreed with the scheme, however they felt that some definitions of process and element in the model were ambiguous. Therefore, definitions were further explained and examples were given to clarify these issues. All findings and results presented in Section 4.3 went through this analytical process to ensure reliability.

Guided by CONTACT, we begin our analysis with the most basic aspect of the constructionist model by examining the relationship between the subjects and the object. Then, we analyse Vygotsky's mediation model of activity system consisting of individual actions and tools. The analysis is then extended to the whole community of this system to include emerging rules as well as the DOL that mediate the community. The focus is mainly on the constructionist concept of externalising the internal meanings onto a sharable artefact through mediation. More specifically, we look into:

- Subject and object: What are the constructionist actions that act on the object and transform the object into outcome?
- Action and operation: How do actions shift to operations and vice versa? How do tools mediate individual actions and operations? What is the nature of the mediating tools? How do they support knowledge building?
- Negotiation and agreement: What is the negotiation that transforms the object to outcome? How do negotiations shift to agreements and vice versa?

- Rules and DOL: What is the nature of implicit and explicit rules that mediate collective actions (negotiation)? How is DOL manifested in the community? How do rules and DOL support knowledge building?

Note that the analysis is not only limited to the above aspects. There are various ways of looking at the data using CONTACT, but for the purpose of clarity and due to the limitation of space, we chose to focus on four aspects which we trust are the main strength of the model.

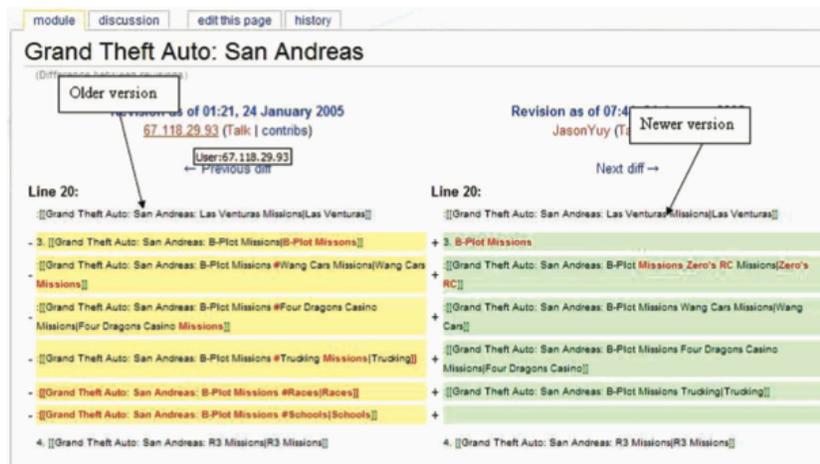


Figure 9: The version compare function

4.3. Findings

4.3.1. Individual actions: subject and object

An individual action on the object is the focal point of a KBC. It is the foundation that all other collective actions build upon since a single contribution from an individual subject will invite more actions and inter- actions among members in the activity system.

Therefore we first study individual actions from the history entries of each page. Our initial analysis is centred on the nature of actions by excluding the interaction among the participants. As this stage, we study an individual engaging in goal-oriented actions to expand the Wiki page. By reflecting on the goal of each action, we identified six categories as shown in Table 3.

Figure 10 shows the number of occurrences of each action category. Note that these actions might become autonomous operations through practice. This will be discussed in more detail in Section 4.3.2.

The first and the most important category is the book content which is the targeted knowledge of the community. This category involves adding, editing and deleting content. Apart from game information in the form of texts and pictures, this also consists of meta-book content, the information about writing the book such as FAQ (Frequently Asked Question) and project meta pages. It can be said that the goal of this category of actions contributes directly to the outcome of this activity system.

Like its antecedent Wikipedia.org (Emigh and Herring, 2005), the game Wikibook aims for a certain level of formality and standardisation of language use, such as barring informal abbreviations and slang. Thus, the second category (writing style) of actions is directed towards providing a homogenous style of writing and avoiding ambiguous meanings. An example of such actions is presented below:

64.175.238.38 (09:51, 8 May, page_4)

Changed from:

Also starting in the small towns like Angel Pine will make it a lot easier and faster to beat, since the people spawn about 10 secs away from the hospital.

To:

Starting in the small towns like Angel Pine will make this mission a lot easier, since the patients spawn about 10 seconds away from the hospital.

The third category (English language) involves language-related actions such as correcting spellings, grammatical errors and punctuations. The goal of this category of actions is to produce error free and correct sentences.

The fourth category is structure and can be generally divided into two sub-categories: internal structure and external structure. Internal structure refers to the modification of organisation and layout of the content (including texts, images, etc.) in a page. It includes moving text to different locations, grouping text in a new section, etc. External structure refers to the creation and editing of links among pages. It is observed that the book starts with no clear external structure; as information grows substantially, more pages are created and linked to each other in order to provide an accessible structure to the reader. From our observations, a huge amount of effort is put into modifying the external structure such as creating anchors, changing page names for linking, indexing, creating navigational links, etc.

The fifth category (format) is concerned with the typography and the format of the book including the font type, the font size, lists, tables, etc. The goal is to make the presentation of information more attractive and clearer. The sixth category (Wiki mark-up) is the use of the

Wiki mark-up syntax. Since Wiki provides limited WYSIWYG features, the participant has to rely on the mark-up syntax. While English language and writing style are important for constructing content, the mark-up syntax is important for structuring and formatting the information.

Action categories	Goals	Examples of actions
Book content	Directly related to the collective object, which is to build the game knowledge repository	Adding, editing or deleting the following: <ul style="list-style-type: none"> • Textual game information • Pictorial game information • Meta-book contents
Writing style	To present the information more clearly	Rewording Rephrasing Formality of writing
English language	To present the information correctly	Correcting the following: <ul style="list-style-type: none"> • Spelling • Grammar • Punctuation
Structure	To put the contents in a proper hierarchy and thus more easily accessible	Sectioning texts Creating new pages Indexing and table of contents Adding, editing or deleting: <ul style="list-style-type: none"> • Links among pages • External links • Navigational links
Format	To make the contents tidier and more readable	Adding, editing or deleting: <ul style="list-style-type: none"> • Table • Font • Heading • List
Wiki mark-up	To structure and format the contents correctly	Correcting syntax

Table 3: Individual action categorisation

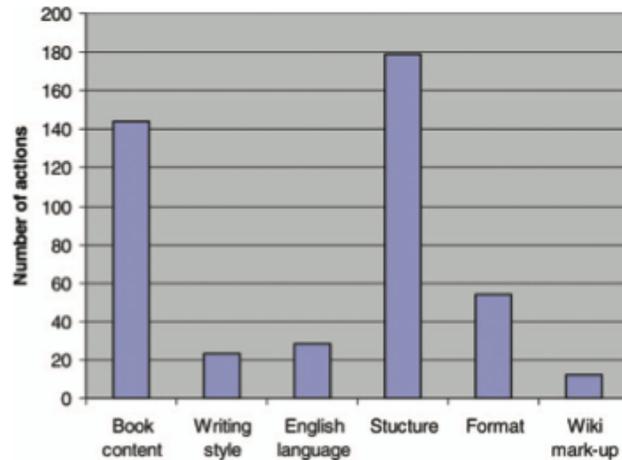


Figure 10: The number of occurrences of each action category

4.3.2. Individual externalisation: action and operation

In this sub-section, we attempt to observe if some of the actions described in the previous section might become operations which, as explained earlier, take place unconsciously.

Typology of DOL	Description	Related actions
Authors	Contribute new information	Book info
Reviewers	Check and correct information	Book info
Proof readers	Check and correct grammar and typos, writing style, etc	English, writing style
Editors	Format the typeface etc, structure the pages and links	Formatting, structure, markup
Vandalism monitor	Control vandalism	--

Table 4: Division of labour.

Negotiation	Goal	Examples
Game content	To resolve the different understanding / mastery of the game	Correct or clarify game information
English language	To resolve the different understanding / mastery of the language	Correct grammatical errors and typos in another participant's writing
Structure	To resolve the different views of what a clear structure is like	Change the structure within a page or among pages
Format	To resolve the different preferences for the format	Modify the format of the text

Table 5: negotiation in the community.

It is important to point out that on encountering changed conditions, we may have to reflect on the operation consciously again, and thus shift unconscious operations back into conscious actions. Referring to the action categorisation (Table 4), we can speculate that due to their nature (i.e. their proficiency is dependent on practice) English language, writing style and Wiki mark-up might become operations as they mediate other actions such as book contents, structure and format. A possible instance of the hierarchy of activity for an individual could be the following:

Activity: to build a game guide

Actions: game information, structure, format

Operation: mark up syntax, English language

The following shows an attempt of a participant, NSRegentPark, to learn the Wiki mark-up language syntax for creating links:

NSRegentPark (13:04, 23 Dec, page_7): attempt to add a link, but the link contains syntax errors ([[“Big Smoke:”]])

NSRegentPark (13:04, 23 Dec, page_7): try to fix the link ([[“Big Smoke:”]])

NSRegentPark (13:04, 23 Dec, page_7): try to fix the link ([[“#Big SmokejBig Smoke:”]])

NSRegentPark (13:08, 23 Dec, page_7): link fixed ([[#Big SmokejBig Smoke]])

It is observed that this participant was trying to learn the mark-up syntax to add a link through a series of individual actions. It seems that the author tried to project his current internal understanding of Wiki mark-up syntax. The externalised object (the particular Wiki page) became a tool that let the participant see and update his/her understanding of the mark-up syntax. For this type of case, those who are fluent in the syntax will perform these edits through unconscious operations.

Since in many cases tools are internalised knowledge (thus operate at the unconscious level), we identify at least two possible mediation tools in this activity: language and Wikis. In addition, the subject of the activity system is the participant of the study and the object is the Wiki page under construction.

A Wiki site as a web technology can be regarded as a physical tool that helps the participant in externalising constructions. It is found that some participants tend to make a couple of changes consecutively. One possible inference is that they attempt to externalise their internal understanding so as to have a closer look at it. The change that is incorporated in the Wiki

becomes the symbolic tool to mediate their next actions. In such cases, a Wiki site can also be considered a psychological tool, as it consists of various signs such as English language and images. It can be said that Wikis help the participant externalise their internal tools (e.g. internal understanding of grammar) and situate them in the Wiki page as external tools (e.g. words, sentences on the page).

For new users who are not familiar with Wiki, the Wiki itself might be initially the object of the activity mediated by simple keyboard typing operations. After being used for some time, the Wiki will become the tool to mediate the ‘real’ objective of this activity which is to create a Wikibook of game knowledge. Further, the tool will be updated when the user encounters a different situation, say to add a table. If the users have not yet learned the mark-up syntax for constructing tables, they have to reflect on the tool consciously again. Thus tools are dynamic and under constant change.

4.3.3. Collective externalisation: negotiation and agreement

A community is not just made up of a sum of separate and unconnected individual actions. Every individual participant is related and interacting with every other in a community to transform the object into the outcome which is a Wikibook of game knowledge. We thus extend the activity system to examine the social dimension to investigate the emerging rules and DOL that mediate the community. Collective actions take place when more than one user is trying to modify the same piece of information be it a sentence, a paragraph or the structure of a page.

We have previously described the collective actions as negotiation and collective operations as agreement. We also pointed out that agreements are usually unconsciously made, while negotiations require conscious effort.

It is worth mentioning that the term ‘negotiation’ is not used in a conventional sense in this context. Due to the very nature of Wiki-technologies, which allow only asynchronous interaction, negotiation is thus referred to as the process of at least two participants engaging in a series of at least two related actions on the same object. For example:

Participant_A (time_1, page_n): modify abcd to abab

Participant_B (time_2, page_n): modify abab to abef

(negotiation occurs)

At this point, we study the interaction of participants engaged in object-oriented negotiation to expand the game knowledge repository. By reflecting on the goal of each negotiation, we classify them into four categories as shown in Table 5.

The first category is the negotiation on the game contents which are most directly related to the outcome. Each participant who plays the computer game comes to the Wiki site with their own understanding of the game (about how to win the game). Therefore, negotiation at this category is the most important and it is focused around constructing information which is socially agreed by the whole community.

The second category is the negotiation of the English language such as grammar. Despite our belief that language is a tool, and thus should be mediated at the unconscious (agreement) level, at the collective level the language mediation does occur at the conscious (negotiation) level:

Dizzle (07:52, 29 May, page_6): typos/grammar, 'duel-wield' is changed to 'deul-weld'

... (other actions)

69.196.128.202 (18:05, 20 Jun, page_6): typos/grammar, 'duel-weld' is changed to 'duel-wielded'

The third category involves the internal and external structure as discussed previously. One of the most common examples in this category is the negotiation on the name of a link. It is found that external structuring is negotiated by a fixed group of two participants. Finally, the fourth category is the typology and formatting of the texts such as the font types:

Master Thief Garrett (04:17, 9 Jun, page_1): add title of the page with different fonts (Beckett, Diploma)

Master Thief Garrett (11:20, 9 Jun, page_1): change font face for the title Old English Text MT

12.220.161.65 (12:34, 16 Jun, page_1): change font size from 12 to 10

Aya (17:28, 17 Jun, page_1): add font template

Like the relationship between operations and actions, negotiations can be transformed into agreements. For example, two different participants might have different opinions on the format of the Wiki page and keep editing each other's format until both of them are satisfied at certain stage. Once this stage has been achieved, new rules will arise and a negotiation is said to have been transformed into an agreement. However, when new conflicts arise, the community has to negotiate it consciously. Once the conflict is transformed into rules, agreements will be achieved. A possible instance of the hierarchy of activity for a community could be the following:

Activity: to build a game guide

Negotiation: English language, game contents, structure, format

Agreement: mark up syntax, writing style

Not all actions need to be negotiated as some actions come to a conclusive agreement. For example, mark-up syntax does not involve negotiation as it is more objective; if one makes a mistake, the mistake can be corrected without conflict. In this case study, there is no disagreement on general writing style either; therefore for the specific Wikibook we are studying it is safe to assume that most participants have agreed to use a formal writing style.

4.3.4. Rules and division of labours

Like individual actions, collective actions are also mediated actions. Collective actions such as negotiations result in transformation of collective mediation such as rules and DOL. When a new negotiation becomes an agreement, rules or DOL will be updated. In addition, negotiations might also result in revising the tool. For example, negotiations on grammar will eventually lead to an agreement that updates the conceptual tool about English in each individual. Indeed, rules and DOL are also some kinds of conceptual tools. But instead of just meditating individual actions, these tools also regulate collective actions.

Like any other community, the community inherits rules from the social cultural background of each participant. Some participants are already part of other Wiki communities before they join this game guidebook Wikibook. However, since every community is to a certain extent unique, existing rules will be amended and new rules will be introduced through negotiations.

This study identified some cases where the rules were made explicit. These rules are written in a specific Wiki page called meta-page and are supposed to be followed and controlled more strictly. These rules are about formatting which includes the template for the format of pages and the linking name convention. While some rules are explicitly written in a page and are followed and controlled, some rules are implicit, like the use of non-abusive language and writing style. These rules are agreed without being stated explicitly and are loosely controlled. Even though this game, Grand Theft Auto: San Andreas, itself contains explicit violence and inappropriate language, it is observed that the Wikibook community generally has agreed to avoid the use of abusive language in writing the game's Wikibook:

206.149.4.17 (18:25, 22 Jan, page_7): add abusive language

. . . (other actions)

69.242.43.174 (14:57, 10 Apr, page_7): the abusive info is removed

Rules make sure that an agreement can be achieved without having to consciously negotiate the actions. The project standard meta-page, once being understood and agreed by the community, becomes a rule to mediate the actions and negotiation on the object page in progress (the object).

The DOL guides the collective actions by setting the roles and responsibilities of the community members. In fact, DOL is a subset of rules that control the division of tasks among the members. In this study, the DOL is not clearly marked in the Wikibook as most participants play many different roles. However, by examining the nature of actions we are able to derive five categories of DOL:

Authors are the game players who contribute new information about the game. Reviewers are usually also authors and they check the validity of the information. As they read, they find errors and correct them. Proofreaders are those who check the correct use of grammar, and writing styles. They might be someone who visits the site to get information about the game and makes corrections on any errors he or she encounters.

Editors keep the page tidy and make it look nicer by formatting the font types, styles, etc. They also help to maintain the clarity of the page structure: e.g. the hierarchy of links. In our study only two participants were actively maintaining the structure. They were also the two most active authors. It was also observed that vandalism results in a new role, vandalism monitoring. For example, there were some participants like, Geocachernemesis, whose only contribution was to fix vandalism:

69.114.183.180 (20:19, 14 Jun, page_7): add nonsense texts

Geocachernemesis (2:01, 14 Jun, page_7): revert to a previous version

Although a technology like this invites ‘vandalism’ (this includes the massive deletion of the text, adding irrelevant contents, using abusive language, and any other actions that are directed against the objective), which was identified in a number of occasions in our study, it is basically controllable. The Wiki itself has the revert function that can reverse a page to its earlier version. In addition, we also discovered that there is a self-regulating mechanism within the community that prevents the website from being vandalised.

4.4. Discussion

Let us revisit our main aims of this study. First, we have developed a model, known as CONTACT, for analysing constructionist learning based on Engeström's (Engeström, 2001) activity theory triangle and Papert's (Papert and Harel, 1991) constructionism. We have presented the findings of an activity analysis of a Wiki community. Based on CONTACT model which draws largely from Leont'ev's hierarchy of activity and Engeström's triangle model of activity system, we successfully cast some light on the constructionist activity in a Wiki-based community. Our findings demonstrate both individual actions and collective actions (negotiation) which constitute activity oriented towards the objective of building a game knowledge repository. We also demonstrated how learning might occur individually

through the action-operation transformation, and collectively through the negotiation-agreement transformation.

Apart from these, CONTACT also helps analyse the tools, capture the rules and the DOL which mediate these actions. These must be further explained in order to differentiate individual mediation and collective mediation. Individual mediation places its emphasis on 'how a user uses the tool to write the game guide, without taking into account how other users act in the community'. In other words, it is about the affordance of the tool to support what an individual can do.

Collective mediation is about the community, which consists of two major components: rules and DOL. Rules define what can be done and cannot be done in a community. This should not be confused with the affordance of the tool. The tool might afford certain actions such as writing in abusive language, but the rules might want to ban this action. DOL is self-explanatory: how the workload is divided among many users in a community.

Based on our observation, individual actions help sharpen the mediation tool, while negotiations bring about new rules or refine existing rules that mediate the collective action. In short, CONTACT is useful to analyse the community in the following ways:

- It helps understand the individual mediation process: subject-tool-object
- It clearly presents the communal mediation process: subject-community-object
- It reveals the emerging rules and DOL in the community

CONTACT appears to be a promising framework as it gives an analytical lens on analysing and interpreting the data. It provides different perspectives of analysis, as it casts different light on the data as researchers can examine it from many perspectives by focusing on different sub-triangles of the activity system diagram. It also helps us examine the learning process: how learning occurs individually and collectively through the externalisation and transformation of hierarchy of activity from action to operation. Furthermore, both individual and collective aspects are given equal importance. CONTACT informs the development of the whole community as well as the individual development. It explains how individual development contributes to the community growth and vice versa. Our second aim was to use CONTACT to get insights on how this kind of communities evolve and develop. In a Wiki space, knowledge is socially constructed; it is created individually with tools, negotiated and agreed within a community based on emerging rules and DOL. It starts as a single unit of information (a page in the case of the Wikibook) and grows organically and evolves into a

complex and well- structured set of knowledge. From our findings, we conclude what contributes to the development of the community is the fact that:

- The users share some historical backgrounds: they already share some of the tools/rules before joining the community, they also share an interest on the same topic (a specific game in this case)
- Users share the same object (goal) (in this case being to build a game guide book)
- A user's individual action: this goal-oriented individual action triggers negotiations that leads to the growth of the space
- The community's agreement on the object: not only the community shares the same object, the community must be able to negotiate and agree on the object
- They share tools that support these actions and negotiations
- They share emerging rules that coordinate the activity
- They follow a DOL that divides the responsibilities

Apparently, the evolution of a KBC needs more than a group of devoted users who share the same object. It also involves negotiation and agreement among the users on the object. Although every user tends to act towards their own goal, it takes the compromise of the entire community to agree on the object.

4.4.1. Practical uses of CONTACT

CONTACT incorporates Leont'ev's conception of the hierarchy of activity within Engeström's triangle model. Apart from this, we have also proposed a collective dimension of the hierarchy, namely negotiation and agreement that explicate the externalisation process at the collective level. These add a new perspective to qualitative data analysis which we believe is applicable for CSCL research. For instance, one of the focuses on CSCL is to examine learners' performance both as a group and as an individual. With CONTACT, we are able to visualise individual and collective externalisation in a community and how these might eventually lead to development. This is particularly interesting in the case of collective externalisation as our analysis reveals that this kind of externalisation might lead to individual development or collective development. One example found in our study was that the negotiation among participants could not only result in the development of the mutual understanding of formatting rules but also could cause each individual participant to update his or her personal knowledge about the game.

While looking at a knowledge building or a CSCL community, it is crucial to also look at the mediation tools, which in the case of CONTACT, are divided into individual tools and

collective tools (i.e. rules and DOLs). We trust that this distinction is important, while trying to analyse from both individual and group perspectives, as it helps us identify the development. For instance, when two learners are interacting and acting on a specific learning task, we would like to know if this interaction will eventually update individual mediation tools (e.g. learning to use the interface of the CSCL system or learning certain concepts of the subject matter) or collective mediation tools (e.g. agreeing upon the appropriate protocol of behaving or agreeing upon the role of each learner in the community).

This points to the internalisation arrow added to the original triangle model. In order to fully understand the social dynamic of a KBC, it is noted that at any particular instance, the outcome is channelled back to the activity system, modifying each element of the triangle, thus updating the activity as a whole.

To demonstrate the practical usefulness of CONTACT, we present two possible cases of CSCL in which this model can be useful:

- **Design:** CONTACT can provide a holistic view of CSCL design. For example, when designing a CSCL system, it should be noticed that technologies (e.g. the computers and web systems) are only one part of the design process. Focus should also be placed upon the formation of communities through supporting social dynamics. Possible contradictions (both individual and collective) should be included into parts of the design. Besides, while designing CSCL systems, mediation tools should not mean to be just treated as individual but also collective as well.
- **Evaluation:** as mentioned before, in order to evaluate the learning process of the learners, both individual and social perspectives can be taken into consideration through the individual- collective distinction made by the CONTACT model on the hierarchy of activity which is being visualised explicitly in the triangle.

As such, we believe that the intricate relationship between individuals and groups can be captured through the use of CONTACT.

5. Conclusion and further research

In this study, we investigated how activity theory can help research a constructionist community. Although we were able to analyse and interpret a KBC in light of activity theory, our analysis uncovered some weaknesses of the triangle activity diagram. We showed that activity theory is useful because instead of focusing only on the interaction between the user and the technology or the interaction among users, it includes both dimensions of a

community: the individual and the collective aspects. However, the traditional model of activity system does not fulfil our requirement in analysing the dynamics of knowledge construction in the activity, as well as the interaction of two interrelated activity systems. Our aim is to operationalise activity theory to study/research social constructionist learning activities in order to do that we proposed and presented in our CONTACT model.

Further research needs to be conducted in order to develop useful analytical tools based on activity theory that could be used to design, and evaluate a constructionist community. The new model should overcome the shortcomings of the traditional triangle model as discussed in Section 2.3.1. We would also like to emphasise that the main purpose of this study was not to refine Engeström's model, but to adapt and apply it to analyse CSCL. Refining the model is such a big undertaking that it is beyond the scope of this article.

We must also reiterate the fact that activity theory itself is not limited to what is presented in the triangle diagram as proposed by Engeström. Although his model is useful, it overlooks several significant concepts of activity theory. It is understood that Engeström's model is intended to be open so that it can be used in various domains but this has proven to pose a serious difficulty among the practitioners as some researchers have started to operationalise it so that it is more practical in day-to-day methodology (Korpela et al, 2000; Barab et al, 2001, Mwanza, 2002). Our purpose went in line with these scholars; we expanded activity theory so that it can be used by educators, as well as game designers in general and game community designers in particular.

Most importantly, it should be able to not only analyse human activities particularly construction activities but also the knowledge construction that arises from such activities. Moreover, more empirical studies will also be conducted to further enhance and verify this model.

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