Dynamics of social roles in a knowledge management community

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ABSTRACT

With the emergence of community-oriented Information and Communication Technology (ICT) applications, e.g., Wikipedia, the popularity of socio-technical phenomena in society has increased. This development emphasises the need to further our understanding of how computer-supported social group structures change over time and what forms emerge. This contribution presents the results of a qualitative field study of a Socio-Technical Community (STC). The STC is described from its founding (in 2001) to its sustainable development (in 2006) as well as its transformation phase (2007–2008). The design-based research approach revealed changes of social structures by social roles within the STC over time. The central conclusion is that such STC's – networks of computer-mediated communication and human interaction – evolve a specific kind of social structure, which is formal rather than informal. The results indicate that a group evolves from an informal trust-based community with few formal roles to a STC where the social mechanisms, and not the software architecture, supports knowledge management processes.

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1. Introduction

In the past decade, new community-oriented applications of Information and Communication Technology (ICT) have emerged, e.g., groupware systems or knowledge management systems. These applications have the potential to transform social systems (e.g., groups, communities, companies, universities, non-profit organisations) into socio-technical systems, where socially and technically supported relationships are highly interwoven.

Recent investigations have shown emerging trends as to how social structures in communities evolve. For example, Viegas, Wattenberg, Jesse, and Van Ham (2007) studied the Wikipedia community and found an increase of coordination activities from 2003 to 2007. Despite the potential for self-regulated participation in Wikipedia, "the Wikipedia community places a strong emphasis on group coordination, policy, and process" (Viegas et al., 2007, p. 1530). Viegas, Wattenberg, and Kushel (2004) also investigated the behaviour of Wikipedians in conflict situations: most activity in Wikipedia is not writing new articles but quality control of written articles, rid new articles of false definitions and to mediate between two or more authors (e.g., discussions on spelling). Roberts, Lowry, and Sweeny (2006) have revealed that knowledge sharing takes places when people assume that their reputation will grow through online participation. To conclude, the studies by Viegas et al. (2004, 2007) and Roberts

et al. (2006) reveal that the social structure of an online group evolves over time.

In this study, the trends of social changes will be investigated by describing the change of social roles within a Socio-Technical Community (STC) at Dortmund University of Technology. In a long-term study (2001–2008), the development of a group into an online community was investigated. Instead of designing a socio-technical system from scratch, an environment was provided for such a system or infrastructure to develop.

In the following sections first a definition of communities, social structures, and roles is provided, as well as the main and derived research questions. This is followed by a detailed description of the STC. Subsequently, the research methods are elaborated. Subsequently, the empirical results on the social dynamics of the STC are described; in particular the changes evoked by the STC's dynamic structuring of roles.

2. Socio-Technical Communities (STC's), social structures and roles

Online communities are good examples of typical socio-technical systems (cf. Coakes, 2002). On the one hand, online communities consist of actors who use technical systems to communicate and share knowledge. On the other hand, the technical system influences the interaction between community members. An online community owes its existence to the technical system because the participants share knowledge and communicate 'through' the technical systems (for example, through discussion boards, wikis, or blogs).

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2.1. Socio-Technical Communities (STC's)

Wenger, McDermott, and Snyder (2002) analysed four cases of large firms in-depth, mainly through observation and qualitative interviews. They conclude that communities of practice are generated through social relationships among individuals "who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger et al., 2002, p. 4). They describe seven principles for cultivating communities, which also includes different degrees of community participation (p. 57): the core group, active members, peripheral people, outsiders, and the role of a coordinator. The questions remain whether (a) this general model of a community structure is also valid for STC's and (b) if the social structure changes over time.

Since the definition of Wenger et al. does not focus on online groups, it is expanded with the findings by Preece, Abras, and Maloney-Krichmar (2004) who concluded that their observed online community evolved "according to how people interact with each other using software to support their interactions" (p. 16). Information systems researchers use the term online communities to describe all social groups which have some kind of online presence, but these can differ in the following four areas:

- Group size (e.g., in research on communities, groups with 25 members or less are considered small, whereas groups with 1700 or more are considered very large).
- Primary content (e.g., discussion boards about Harry Potter books and movies, discussions about sports like marathon training, communication about stock exchanges, information sharing about lectures at a university).
- Lifespan (e.g., several years or just single-topic).
- Presence (e.g., pure online communication, face-to-face communication or mixed).

In this contribution, a STC consists of social relationships between people sharing an interest in topics or problems, fostered mainly by computer-mediated human interactions. Depending on the content, lifespan and group size, a STC differs from online communities in that it delivers a kind of interaction space for enabling communication between members and others *within an existing institution, organisation, or company*. A STC can reduce the social complexity and information overload from the official organisation, and makes it easier for a community member to obtain only the information that she or he needs at a given time.

In contrast to work groups of departments in companies, where the group members are formally bound, STC's consist to a larger degree of informal connections between members (Lesser & Prusak, 1999) than formal regulations and roles. Formal structures are characterised by conventional forms of behaviour and established conventions, for example, behaviour that is formally bound by a work contract or a job description (e.g., a teacher, formal moderator). Informal structures are casual, unofficial, loose and not triggered by any rules (e.g., activities of informal moderation). Fig. 1 shows the typical relationship of a STC to the organisation; in this case a university.

2.2. Social structures and roles

Mackinnon (2006) reviewed the literature on the concept of social structures and concluded that the different definitions emphasise "the concept of social structures as a set of elements in mutual relation to each other" (p. 9). For example, Jary and Jary (1991) describe social structure as a "relatively enduring pattern or interrelationship of social elements" (p. 465), e.g., behaviour and relationships within social systems. The notion of social structure as an enduring and relatively stable pattern of social relations, emphasises the idea that social systems or online communities consist of sets of interaction patterns with different functions, meanings or purposes, that can be called 'roles'. It has to be stressed that existing and evolving roles in a STC is one essential observable aspect when investigating the shape of social structures within a STC.

A social role is often defined as a set of activities performed by individuals (Goffman, 1959), but a role also defines the range of expected behaviour within a group. For instance, a person who teaches has special behaviour patterns such as 'giving some instructions to the group', 'beginning when the class starts' or 'standing at the front of the class'. The group expects such activities and labels such people accordingly as a teacher. If the person in the teacher's role would undertake totally different activities, then parents, students or other teachers would probably intervene. They would give negative sanctions and feedback, and interactions or discussions would convince the abnormal teacher to rectify the behaviour. To conclude, a role and its role-playing depend on the pre-existing values and norms of a group, community, social system or society, and the possibility or power to restrict alleged 'incorrect' behaviour. Therefore, a role and its assessment of good or bad role-playing are relative (see also Strijbos & De Laat, 2010).

The role theory was criticised especially between the 1950s and 1970s as not being able to fully explain the complexity of societies. Thus, role theory was no longer considered as a complete sociological theory, but the term 'role' was integrated as a basic term in
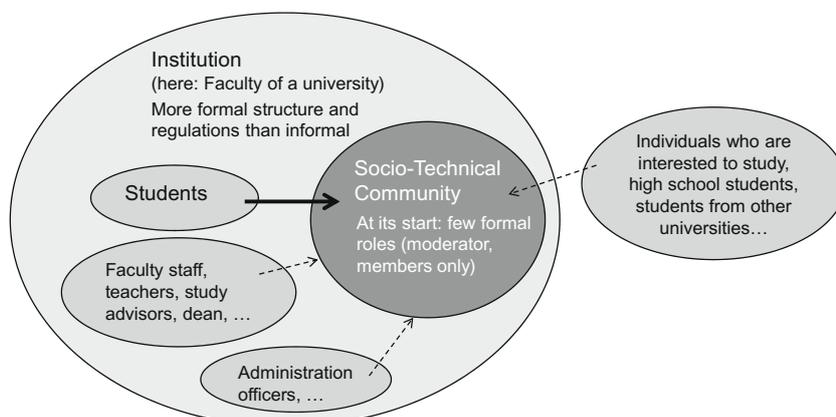

Fig. 1. Relationship of a STC to the official organisation at launch.

contemporary social science. With Giddens (1984) the term role was expanded to include temporal processes and became part of social structures that form the basis of a duality: on the one hand a role is created by those who interact, and simultaneously, there are on the other hand inherited rules, resources, regulations, values, norms and social relationships that are produced and reproduced during human interactions. A role in STC's also depends on computer-mediated interaction, and a role is then a perceivable interaction pattern created 'through' the repetition of social interaction (Bales, 1950) supported by technologies.

According to Herrmann, Jahnke, and Loser (2004) a role consists of four combined characteristics: (a) position/social relations, (b) tasks/activities, (c) expectations/trust and (d) online interaction/role-playing. They derived these characteristics from historical discussions about the term role: from symbolic interactionism beginning with Mead (1934), Goffman (1959) and Blumer (1969) – to the functionalistic paradigm beginning with Linton (1936), then Parsons (1951) and Dahrendorf (1958).

2.2.1. Position/social relations

The position means the member's position in the group, organisation or community in relation to other members (see also Sarmiento & Shumar, 2010). The position can be a formal one, such as student, teacher, study management advisor or moderator, assigned by work contract or membership. It can also be an informal position like opinion leader, conclusion-maker or promoter of the procedure. The term 'position' has no relation to a physical location. Table 1 shows examples of formal roles in an organisation and STC.

2.2.2. Tasks/activities

This aspect focuses on what an organisational or community member in a specific position does or what this person is expected to do (from the viewpoint of the community or organisation), what the different primary activities are, for example, teaching, consulting, moderating, and/or contributing. Tasks and activities are often close to the position held by a person.

2.2.3. Expectations/trust

Here the term expectation refers to what people expect a role owner, depending on a specific position performed by an individual, should do or not (Jahnke, 2008). From this point of view, expectations are indicators of social structures since they can illustrate how social elements are related. In official organisations, expectations are often linked with the job description. In addition, people have positive expectations regarding the motives and expertise of their peers. They trust each other when they get help. Trust is "the positive expectation a person has for another person, organisation, tool, or process that is based on past performance and truthful future guarantees made by a responsible person or organisation" (Shneiderman, 2000, p. 58). Trust is something that people expect rather tacitly than explicitly. "When there is trust among

people, relationships flourish; without it, they wither" (Preece, 2000, p. 191). In contrast to official organisations, a STC is often built solely on trust. Online communities exist in a state of pre-trust. Betrayal of trust can have a marked negative impact on the online community and can limit or dissolve collaborative learning. Trust-building can be supported by social awareness tools. Dourish and Bellotti (1992) define awareness as an understanding of the activities of others which provides a context for the person's own activity. In other words, awareness occurs when people see what happens in the group. The more a person's expectations regarding others are accurate, the more one can trust the behaviour of others, which engenders mutual trust. Awareness can increase the accuracy of one's expectation, because it gives access to more examples of another's behaviour, and from that larger pool of examples expectations can be refined.

2.2.4. Online interactions/role-playing

People have expectations about what a role owner should do or not, but a role is a dynamic phenomenon and therefore can also be changed by individuals. As mentioned previously, such changes in behaviour occur in anticipation of people's power that could restrict non-conformist behaviour. These dynamic interaction patterns can metaphorically be described as 'role-mechanisms'. Role-mechanisms describe how people take a role or assign someone a role. Examples of role-mechanisms are role-assignment, role-taking, to allow someone's role-taking, role-changing, role-making, and role-(re)defining (Herrmann et al., 2004). Role-making (Goffman, 1959) characterises how a person plays a role, and how she or he transforms the assigned expectations into concrete behaviour. This depends on the interaction process where people negotiate such expectations being significant for a role. The problem (from the community's point of view) is that a role actor has a certain attitude to the role (role-distance) and this attitude can differ from what the original expectations intended (Goffman, 1972).

In sum, social structures consist of roles. To observe roles, the four characteristics have to be empirically observed. Position/social relations and, expectations/trust characterise the *structural dimension* within groups, i.e., how people relate to each other. Task/activities and online interactions/role-playing mainly focus on the *action dimension*, i.e., how a person performs the position and plays the role. The combination of characteristics can sufficiently describe the possible change of roles within STC's.

2.3. Research aim and derived research questions

The main research question can be summarised as: do roles as representatives for social structures within STC's change over time and if yes, what forms of changes will emerge? The aim was to observe any changes of social structures, informal or formal. More specifically the following derived research questions will be investigated:

(1) Do social relations change in STC's over time? Do members only communicate factual information (aspect of content) and/or could one observe indices about their relations to the other members (aspect of position)? According to Herrmann and Kienle's (2008), one can communicate on the level of 'content' and/or 'relationship'. With regard to the STC's within universities, students might discuss content on online boards (for example, about lectures) or they may also foster relationships within the community, for example, from weak to strong ties or vice versa (Granovetter, 1973).

(2) What do the community members do, what are their primary activities (e.g., moderating, lurking, contributing, or something else) and in which direction will it change over time?

Table 1
Formal roles in the official organisation and the STC.

Formal roles	
Via contract/enrolment	Via membership/account
Official organisation	Socio-Technical Community
Faculty at a university	in its initial phase
Examples	
Students	Members
Faculty Staff	Moderator
Study management advisors	
Teachers	
Administration officers	
Dean	

(3) When a community member's expectations regarding other members are accurate, do the members build trust? It should be kept in mind that trust is an expectation that may show in what ways community members are related.

(4) What kind of online interaction patterns (focused on moderating activities) emerge?

These questions have been studied through a long-term in-depth field study of the development of a STC. In the following section the background for establishing the online community will be elaborated, and subsequently the research design and instruments.

3. Methods

3.1. Background

The project on 'Organisational Development of the Computer Science Studies' at the Dortmund University of Technology (Jahnke, Mattick, & Herrmann, 2005) revealed many information deficiencies – from the perspective of students – relative to the roles at a German university, e.g., teachers, students, student advisors within faculties, administration officers for examination regulations, enrolment office, technical-support at the media and IT centre, study manager for the entire university, library contact person, planer for lecture hall and rooms, secretary at the deanery and many more (the entire list is in Jahnke, 2006, pp. 144–145). These roles are called formal roles and focus on behaviour performed by people with regard to their contracts at the university.

The project concluded that German students, who decide themselves when to attend lectures or seminars, had a lack of information about how to choose their lectures, in which semester to choose them, and how to plan and manage their studies. This lack of information lengthens the average period of study (standard length of an undergraduate computer science degree in Germany should be 4–5 years, however the majority of students take 6–7 years to obtain their degree). There was also a lack of feedback and assessments from study managers on students' progress. To solve this 'lack of information', the development of a knowledge management community was studied.

In contrast to the formal roles at the university, the socio-technical knowledge management community consists, at its inception, of informal rather than formal roles. Informal roles are not assigned by a contract, they are not triggered by any rules but they are observable via interaction patterns and activities like active people, coordinators, peripheral people, and lurkers.

3.2. Context: The InPUD-community as a Socio-Technical Community system

Based on the project's results, an ICT system, called *In*formatics *P*ortal *U*niversity of *D*ortmund (InPUD), was implemented to solve the information deficiencies by supporting knowledge sharing between novice (new) and expert (senior) students as well as faculty members and other formal roles in the context of study administration. The InPUD-community (http://inpud.cs.uni-dortmund.de) can be described as a 'virtual knowledge sharing system' for computer science students at a German university. The first prototype was launched in 2002.

The InPUD-community differs from other communities which are built in people's spare time and which are not a part of a company. InPUD is an extension of the Department of Computer Science; i.e., a supplement to the formal structure. According to Preece's four areas the InPUD-community is (a) characterised by a large size, (b) the content of the InPUD-community is knowledge about computer science and its study management at the univer-sity, (c) its lifespan is already multiple years (ongoing), and (d) InPUD is a pure online community.

First, the InPUD-community includes an overview of all classes and lectures that are offered during the course of a semester. The way that the information is structured is the same for each lecture or seminar. The information is about lectures, including any tutorials that are being held (and when), course materials, notices for examinations, lecturer contact information and often a free discussion forum as well as news and search functions.

Second, since German universities offer a large variety of lectures, students have to create their own semester plan for lectures and choose which lectures they attend and when to attend them. Therefore, the information about the study management domain was combined with online discussion boards. The boards are embedded in an information website that includes facts about course guidance as well as graphical maps of how to study which course at which time. The discussion boards exist for both lectures (e.g., to discuss exercises or content of lectures) and study management, for example, 'how to study successfully', 'how and where to register for examinations', 'where to find the university calendar (timetable)', etc. The decision about the topic on each discussion board mainly depends on what the students want to discuss. It ranges from discussions about course content, definitions or solutions for exercises to organisational issues, e.g., where and when is the next learning group, what could be the content of the examination, or discussions about the teacher. The last point is a critical one especially when the students criticise the teacher's instruction.

In 2008, there were more than 40 boards online, each with their own moderator. Fig. 2 shows a screenshot of InPUD and illustrates the main components.

Community members can share their knowledge under the condition of a minimum of formal regulations and limited university control. That means, every member can read any of the InPUD-content without login and registration. In contrast, to answer or pose questions requires a brief registration (username and email address). This process is different to learning management systems (LMS) which often require registration with a full name and an official status at the university.

3.3. Research design

From 2001 to 2008, a long-term field study was conducted with a design-based research (DBR) approach (Reeves, Herrington, & Oliver, 2005). According to Wang and Hannafin (2005) DBR is "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually sensitive design principles and theories" (p. 6). In other words, DBR consists of several phases of analysis (reflection) and design (interventions for improving a socio-technical system or community), which are alternated and interwoven (cycle of activities), see Fig. 3. DBR research aims to understand the social or socio-technical phenomenon as well as to improve its quality. DBR researchers fulfil several roles like researchers, designers, or practitioners (e.g., teachers).

In the case of InPUD the goal was to create a living knowledge management system (practical aim) and to research the forms of organisation of computer-supported social groups and if/what new social structures emerge (aim with regard to the theory of sociology and socio-technical systems).

It has to be stressed, that the present research approach is based on the sociological qualitative approach of 'grounded theory' (Strauss & Corbin, 1990) in combination with a hermeneutic approach in order to exploit something new from the field study. In sociological research, the interpretative paradigm is used to

Fig. 2. Screenshot of InPUD's functionalities (before its transformation in 2007/2008).

explore the socially constructed contexts of institutions and organisations (Berger & Luckmann, 1967). According to this paradigm, the researchers do not have defined criteria or variables in the initial phase since they do not know them. Following this paradigm means to interpret and understand social cases by analysing their meanings to the human participants and their culture and structure. Similar to DBR, the major goal of the grounded theory approach is to generate theory to solve practical problems.

This qualitative interpretative paradigm is well-suited for a long-term field study in which interviews and other forms (e.g., participant observations; written communication in online boards,

interviews, talks with stakeholders) from a rather small number of cases are closely read, analysed, and interpreted. The present
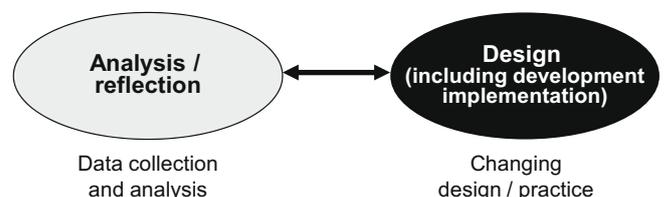

Fig. 3. DBR design in general.

investigation did not have measurable variables or quantitative hypotheses before its start, since a clear picture of what was going on in STC's at universities was missing.

Nevertheless, there were prior assumptions based on the four characteristics of roles (that are part of the social structure). This means that a change was expected to be observed in the following forms: member's positions (relationships), tasks (here focused on community activities like posting, lurking or reading), expectations (here specialised on trust), and online interactions/role-playing (in particular, formal or informal moderations). However, there were no ideas to which degree or forms it could change. In addition, it was assumed that STC's are rather informal and would stay at this level over time.

3.4. Instruments and procedure in a chronological order

The hermeneutic approach that was integrated in the DBR design of the long-term field study included the following phases of data collection, methods, analysis as well as interventions.

Phase 1 (analysis by qualitative interviews): From 2001 to 2002, 14 people were interviewed face-to-face (8 students and 6 professors/lecturers who were experienced study counsellors) with an interview guide including open-ended questions. The objective was to find out how to support the students' problems within their studies with a living knowledge management system.

Phase 2 (intervention): The results of the interviews (phase 1) generated the idea to create an information portal which would offer an overview of lectures in each semester, a graphical plan of the first four semester foundation courses, and information from the study management advisors. In May 2002, the first prototype of the community system called InPUD was launched.

Phase 3 (reflection by questionnaire and beginning of ethnographic online observations): After the prototype, a standardised questionnaire was created which was sent out to a sample of the computer science students at the University of Dortmund (out of 430 questionnaires, 384 were returned). The sample represented approximately 20% of all computer science students enrolled on foundation courses). The aim was to gather initial ideas for improving the InPUD prototype.

Phase 4 (intervention): Based on the questionnaire and its results for the InPUD prototype, a discussion board about study management as well as courses was added. The new functions were launched in September 2002. So, the 'static information' about the study management domain was interwoven with 'dynamic online discussions'.

Phase 5 (analysis by interviews/small survey): In 2003–2004, eight international experts in the field of study management as well as 'university management', who had experience in web-based learning management systems, were interviewed. The aim was to find out what the crucial factors for successful study management are, so as to compare the experts' statements with InPUD's development. In addition, a small quantitative survey was conducted at the Faculty of Computer Science; 186 questionnaires were returned).

Phase 6 (intervention): Based on the results from phase 5, the InPUD-community was supported with new ideas, e.g., giving members with formal roles a name representing their role and making roles visible (the study management advisors were labelled explicitly).

Phase 7 (analysis by online ethnographic observations, and statistics): Participant observation was performed on the online discussions in InPUD (especially 2003–2006). The communication structures were studied, as well as a qualitative content analysis on computer-supported social interactions, and social relations. The investigation also considered user statistics and log-files (webpage requests 2002–2005; online board 2002–2008).

Phase 8 (intervention): Because of the transformation from the traditional German 'Diplom degree' to Bachelor/Master courses at the University of Dortmund, InPUD needed new information (e.g., courses and content as well as changes about study planning and organisation) and has been updated commensurately.

Phase 9 (analysis/questionnaire): In 2008, a small quantitative survey including standardised and open-ended questions was conducted. An evaluation is planned.

The field study was situated in the natural setting of the users. The tools for analysis and interpretation were mostly qualitative techniques such as ethnography, participant observations, interviews, and documents as sources of data (e.g., material from the discussion boards). The data from phases 1, 3, 5 and 7 were recorded through audio, or notes were taken by an observer and later analysed using open coding (Bryman, 2008). The validity of the qualitative analysis was checked by different researchers. In addition to phases 3, 7 and 9 the questionnaire, statistics and logged files were analysed by using frequencies and correlations.

The results of the field study will be described in the next section, arranged by the four characteristics of roles (position/relations, tasks/activities, expectations/trust, and online interaction/role-playing).

4. Results

The analysis focused on changes in social structures, and in particular the development of roles in technology-mediated STC's. The four characteristics of a role – position/social relations, tasks/activities, expectations/trust and online interactions/role-playing – will be used to structure the analysis of InPUD.

4.1. Position: Different types of social relations – Just-in-time when needed

Since InPUD's launch in September 2002, the number of users has increased steadily (Fig. 4). In September 2008, more than 1470 individuals have an account. This represents 73% of 2000 students enrolled at the faculty and confirms the growth of the community over time and its evolution.

Fig. 4 reveals a drop of new users in 2007, which was the year a lot of German universities transformed their courses from the typical Diplom degree into Bachelor and Master degrees. Because of this new development, some potential students were waiting to see what would happen in the universities and did not enrol or contribute.

Fig. 5 shows the number of contributions per individual in seven posting categories over the entire period from 2002 to 2008 (September). Over a time span of more than 5 years, 1166 mem-
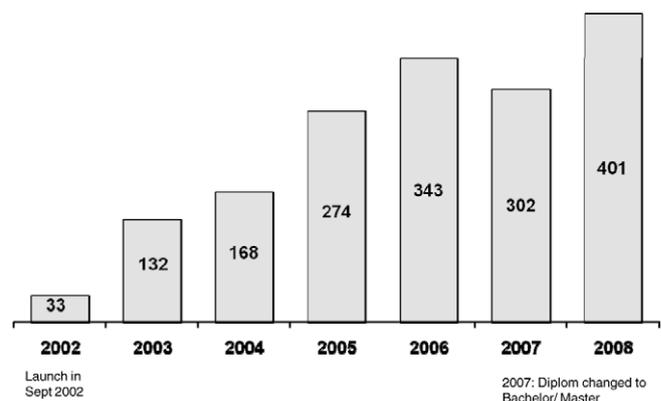
Fig. 4. Frequency of new InPUD users per year.

bers contributed actively (1478 – 312, cf. Fig. 5). A core (of about 270 individuals) provided contributions regularly, ranging from 26 to 483 postings per individual. The core members are especially the 'early adopters' and from today's viewpoint the 'elders'. These people have been active since InPUD's early years. However, some of the core members in InPUD are also new students between the first and fourth semesters.

The other active members made postings in the range from 1 to 9 and 10 to 25. These members can be described as regulars, but also include novices and visitors (e.g., high schools students, students from other universities).

The other 312 registered members did no posting (contribution is 0). According to Preece et al. (2004), there are various reasons for why they do not post (e.g., no motivation, no personal need, and curiosity without exposure). An explanation for InPUD is that these registered InPUD-lurkers (15.6% of all 2000 students) want to show their interest in the community although they do not actively par-

ticipate. They maybe waiting for the right moment to post or they do not know that registration is not obligatory (this was mentioned in an interview by just one student, but this student added that it had happened to other students as well). The percentage of lurkers (registered but non-contributing users) – or as Lave and Wenger (1991) would say the 'peripheral' users – is supported by a chart where the number of contributions are split by year (Fig. 6). There is a second level of lurkers, those who are not registered: about 500 of 2000 students (approximately a quarter). The quantitative survey shows that almost half of them are still readers, whereas the others did not use InPUD. This analysis shows that the community consists of different social relations since different types of communication – core, active or less active members – are related in different ways.

Fig. 6 shows the number of contributions in relation to the number of individuals in seven posting categories for 2003, 2004, 2005 and 2006 (2007 was excluded as it is very similar to 2006
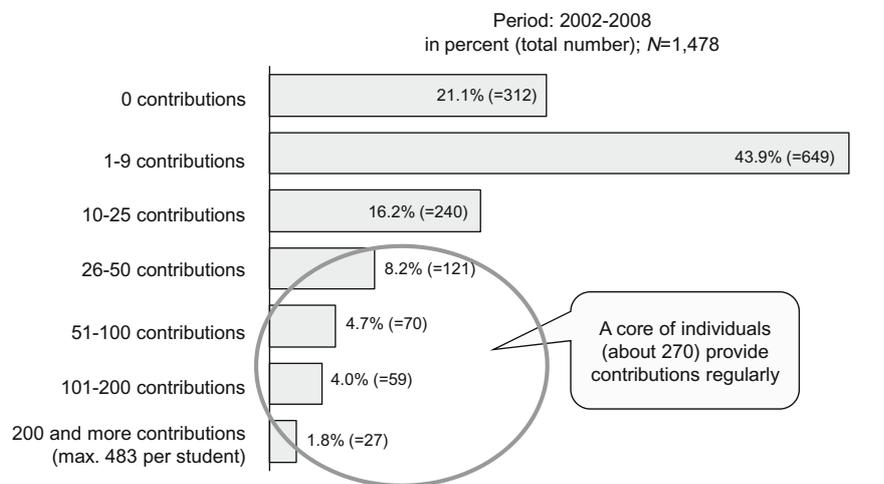

Fig. 5. Absolute and relative frequency of users contributing in seven posting categories.
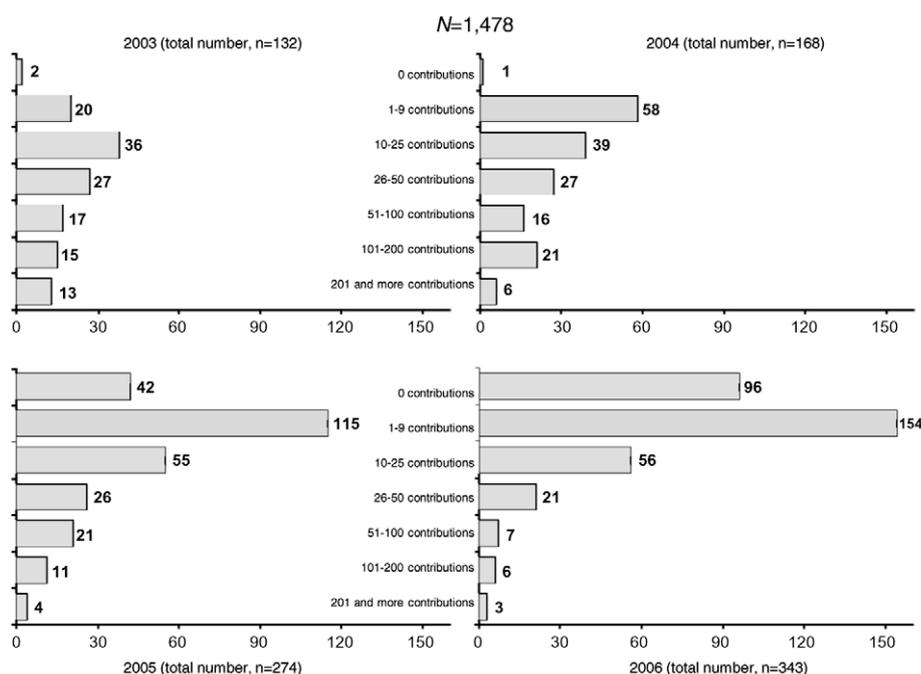

Fig. 6. Frequency of users contributing in seven posting categories per year.

and for 2008 only data for September was available). The total number of users has increased. For example, 20 new users each made 1–9 postings in 2002. In 2003, there were an additional 68 individuals. In 2004, there were 116 new users, and more than 160 new members in 2005. However, an average member posted more in 2003 and 2004 than in 2005 and 2006. For example, in 2003 16 individuals posted 101–200 contributions (each of them!) and in 2004, 21 users posted a similar amount. In comparison, just 11 users in 2005 and 6 members in 2006, contributed this many postings.

In summary, the large number of registered users (1478/2000 = 73%) indicates that many students appreciate this form of information and knowledge sharing, for example, they discuss and come up with new ideas and help each other. Furthermore, a close examination reveals that positions/social relations have changed to more contributors in 2006, and the trend is continuing. However, the quantity of contributions per individual has decreased. These results in particular, give qualitative hints that different types of ties have occurred within the community. The following paragraphs illustrate the results in more detail.

In contrast to InPUD's early phase, where just 3 online boards for questions regarding study management and only 2 boards for courses existed, InPUD has integrated more than a total of 40 boards in 2008: 39 courses, 8 for study management and 5 for other issues like studying abroad, and studying and living in Dortmund. On such boards the content as well as the time between questions and answers was observed. In InPUD's initial phase, the study management boards mainly consisted of questions with regard to organisational issues such as "where is the administration office?", "when should I do my examination?", or "when does the written examination take place and where?". On such boards there was typically one question followed by one correct answer.

In 2008, with the increase of boards including courses and content of computer science studies, a change in the way the members communicate and discuss appeared. A typical example is a question posted on a discussion board of a lecture with 80 students. The question of student A was posted at 4.27 pm and was concerned with what a 'socio-technical system' is. The first answer came from student B at 4.34 pm – only 5 min later. Student A replied and posted a comprehension question at 4.53 pm. Student C posted a comment at 5.30 and student A replied at 5.55 pm, writing "Now, it is clear to me. Thank you!". Just 1 h and 28 min elapsed between the posted question and the acknowledgement of understanding. The following day at 11.48 am, the lecturer confirmed some ideas posted by student C and added new ideas and information. Thirty minutes later, student A thanked the teacher as well as the other users again. This typical example shows that InPUD-members combine their knowledge in a collaborative effort.

With the increase of boards including courses and content of computer science studies, a change occurred from providing information to a collaborative discussion that integrates active learning and knowledge construction. The community can enable its members to build social structures and active social interactions – *as and when they are needed*. In addition, Figs. 5 and 6 show that some members posted more often than others. One student made 483 postings (mostly answers). Students who contribute to InPUD and give regular answers to the InPUD-community are more visible within the community than those who are one time contributors. An explanation for the motivation behind this social interaction emerged in the interviews. Some individuals wish to 'break out' from the anonymous mass (the large student group with 2000 members), or they simply want to help. However, there is a cost-benefit-calculation involved: "I help because he/she, or another community member, will hopefully help me when I need support" [quote of a computer science student 2003].

InPUD gives the community members the opportunity to find people who share their interest for the same topic, problem or passion within a large anonymous group. We call this phenomenon 'computer-mediated social proximity' since it was triggered 'through' the medium of the technical system (especially through discussion boards for lectures and study management issues). Evidence from data for such an online proximity is that the members who interact and help others, also say "thank you" or wish "good luck" with exams. These are typical communication phrases in InPUD. We observed a thread without any factual information just with the topic 'acknowledgements'. A student wrote "I only want to say 'good luck' for all of you for the written examination, and thanks again!". Some members answered with similar expressions and showed their appreciation. Some discussions also drifted from the content to personal interests (e.g., "where do you live?"). The online community gives the students the chance to keep in touch with people who share the same problems and to establish a kind of social proximity.

4.2. Tasks/activities

The InPUD-community has many participating members – hundreds of people who give ideas or share their knowledge online. During the initial stages (2001–2002) the majority of the InPUD-community's members occupied the same position. Tasks were transparent for each new member. The main tasks at the outset of InPUD were as follows:

- Posting/contributing (function: provides information for the community or asks questions).
- Only reading (function: takes the information and spreads it to the outside world).
- Formal facilitating by academic staff (function: establishes rules, checks conventions).

In the initial growth phase (from 2003 to 2004) the members began to employ new forms of communication, which can be defined as 'informal posting activities'. For example, some core members took up the part of the informal moderator. They did not have the formal role of a moderator but guided the other members. The InPUD-members developed a common culture of participation. Table 2 provides insight into the differentiation of informal posting activities (adapted from Herrmann et al., 2004) and reveal that the InPUD-community was able to build new informal activities during its growth and that students were the driving force behind InPUD.

In InPUD's sustainable development phase (from 2005 to 2006) and its transformation phase (from 2007 to 2008) many new members in particular took up formal roles (e.g., moderating tasks by lecturers, academic staff and professors). These members also started a lot of new topics on discussion boards (e.g., studying abroad, women in computer science, new courses). The increased participation of the students encouraged the staff to become more involved in the online community. Nevertheless, the core members did not stop contributing and they remained the informal managers.

4.3. Expectations/trust

Online communities build their potential on the basis of trust defined as positive expectations of another person's behaviour. Trust plays an important role since it is something that people expect rather tacitly than explicitly and the betrayal of trust can adversely affect collaboration and community building.

The process of trust-building in the InPUD-community relies on online written communication, which makes trust-building more

Table 2
Informal posting roles from 2003 to 2004 (adapted from Herrmann et al., 2004).

Informal role	Description of informal posting activities	Typical InPUD examples
Author	A member who contributes information and communicates own ideas by writing short statements. InPUD-members add their own contributions and ideas	"It would be nice, if the department had a central website with all information about the computer science courses. InPUD is a good idea. Unfortunately some people in the department do not work sufficiently with InPUD"
Scaffolding	A member who provides structure to the discussion	"Please, look at the thread of study management, before you ask the same questions as the others" "This question was already answered in thread 19"
Reading as visitor	Someone who reads contributions of other users and is primarily interested in getting an orientation without making own contributions (gets inspiration)	"I am not a member of this university"
Conflict-mediator	A member who acts as a mediator in emotional conflicts (e.g., when two or more members have a dispute) and intervenes in emotional discussions (to enable the discussion to continue)	"I understand your problem, and it is good that you want to change something, but this thread is not the right way to solve your problem. Would you mind talking with the professor face-to-face?"
Technical-support	A member who explains the use of the technical system	"Why is the board so often offline at the weekend?" The answer of the technical-supporter: "A person told me they are upgrading the software. The new version should work in 2 weeks. Hopefully, they are right"
Conclusion-making	A member who adds comments to postings and has an essential influence on the content of the discussion	"From my point of view, it looks like…" or "Summarised…"
Promoter of the procedure	Someone who makes the current procedure more transparent, supports task completion, positively promotes the discussion or activities and motivates to participate	"Yes, I could explain the seven answers of the exam after the exam – when there are enough students who will participate. I suggest Wednesday, 14 February, I am in room E28. I will not do this if there are just 3 or 4 people, so, come on, and all come to the meeting"
Organisational-supporter	A member who provides another view of the activities (meta-level: communication about the communication), support to think about organisational conventions (e.g., how to communicate)	"Why have you written this posting three times? Please, wait a moment before you write it again" "You say that someone says the script would be online, but where is it and who said this?"
Decision-initiator	Someone who combines diverging contributions by relating them to a summarising statement; if the discussion diverges, the person calls for an informal vote to reach consensus	"Do we share this view of the problem?"

difficult due to a lack of facial expressions and/or physical presence. Additionally, the InPUD-members do not generally know other users outside of this virtual space. Hence, three areas of trust can be distinguished:

- Trust in the identity of the others: who is the person behind the name on screen?
- Trust in the interests and motives of others: which interests/ motives does (s)he follow/have? Why does (s)he communicate with me? Is the person acting in good faith and giving honest statements?
- Trust in the expertise of others: does (s)he know enough to help me?

Since InPUD's launch in 2002, the number of webpage requests has grown consistently and the access rate usually peaks at the beginning of a new semester. In October 2002 there were only 171,408 requests. A year later, in October 2003, there were 292,155 requests and in October 2004 this had increased to 491,330 requests.[1] These requests are continually increasing without marketing or any external advertising (see Fig. 7), which reflects a high degree of overall trust in the information provided through InPUD.

The trust-building process in InPUD was supported by ensuring that each discussion board had one or more formal moderators, a task that academic personnel are obliged to perform. However, there was no rule how often they must moderate. In the first years (2002–2004) the formal moderators rarely moderated, ranging from 2 to 50 contributions per year, but the quality matters most

and not so much the quantity. An interviewee [student council, 2003] remarked:

"There is also a Yahoo group for computer science students in Dortmund. But one problem is some people write a lot of totally odd things. Maybe that's a problem since this online group hasn't a direct connection to the faculty. That's perhaps also a reason why InPUD works, and the people have a rather proper behaviour. Most of them don't write off-topic things. There are some little exceptions, but I mean, maybe the faculty doesn't do anything but still the idea the faculty staff is there [in InPUD], affects the students' positive behaviour in InPUD. And, I think that matters most, almost always bad or wrong things or answers get a comment. And often the moderators comment. Of course, all the students expect that false information will be deleted or commented, and up to now it works".

At least in the initial, as well as growth phases, the members could be relatively sure that incorrect information would be commented on. The formal moderators gave the InPUD-community the structure for facilitating trust.

The trust-building was also supported by InPUD's transparency. First of all, InPUD clarified the context. For instance, InPUD was obviously a part of the Faculty of Computer Science. In contrast to the Yahoo group, InPUD is connected to the university (displayed by the university logo, legal information, contact field, and so forth). Secondly, commitments on 'how to behave' were clear, since each board describes permitted content and announcements that "off-topic discussions will be deleted". The communicative style – 'netiquette', a set of rules governing the behaviour of members – affected the development of the community, and it supported the trustworthiness. One such typical case in InPUD was as follows: a student was annoyed about a lecture and asked

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[1] Because of technical problems with the InPUD server in 2005, we have only webpage request statistics until February 2005. Fortunately, the InPUD forum was not affected by these problems (see Fig. 3).

in an agitated tone: "What the hell does the professor do? I don't understand anything!". In response, some students generated a "true vote for the mood in our lecture". Some members commented on the 'unexpected' remark as "not okay" ("You are not striking the proper tone!"), others ignored his behaviour, did not answer, and opened a new thread. Cleary, social mechanisms were in place and working. Finally, the InPUD forum provided an awareness tool with information about activities of other users, formal roles and current status, including who and how many users were online at a given time. These tools provided the community the opportunity for (re-)modelling and renewing trust (Hoffmann, 2004).

However, the rather positive trust-building process changed in the phase of transformation (2007–2008). In 2003, over 90% agreed that InPUD was positive. In contrast to a quantitative survey in 2008, where the community member were asked: "InPUD is good", because…", "InPUD is improvable because…", "InPUD is bad because…" (a combination of closed and open-ended questions). Out of 145 answers, 48.2% replied 'good', 41.1% wrote 'improvable' and just 7.5% answered "InPUD is bad". One main argument was the problem with correct and complete information as expressed by two student remarks: "we need more information" and "often InPUD is good, but, sometimes we cannot trust in the information we get, because we don't know if the information is correct, for example, the room plan for classes changes in a short time". It appeared that the members' expectations were not being met in the later phases, and it seems that trust decreased or at least that it is declining.

4.4. Online interactions/role-playing

The data shows that the community members were primarily students from the Faculty of Computer Science at Dortmund University of Technology, at least in the early years, between 2002 and 2003. The questionnaire that was distributed in 2003 revealed that 93% of the students were familiar with InPUD. In the initial growth phase (2003–2004), new informal roles emerged; for example, the interaction pattern of active people, the promoter, the conclusion-maker, the decision-initiator and the conflict-mediator (see Table 1). Particularly in the first stages of InPUD's development, students were often the only ones who answered an open question. The active students also took part in informal moderation activities. These informal moderators

helped other members and told them "how to ask questions" or informed them that "that question has already been answered on board 6". Of course, there were also some formal moderators who gave support when open questions were not answered. However, comments from them were extremely rare.

In the interview phase in 2003, students told us that a Yahoo group for computer science students in Dortmund existed (see also the section on expectations/trust). They described that participation had decreased since InPUD was launched [quote of a student from student council 2003]:

> "There is also a Yahoo group for computer science students in Dortmund. But it's just an independent separate group. Open, no structure – it's just a student self-organised group. Not really helpful. This online group [Yahoo] hasn't a moderator who is from outside; a moderator who isn't from the same group. InPUD has always at least one moderator from the faculty staff. Well, they could actively moderate more often. But they are there, that's better than nothing".

The formal moderator from 'outside (of students)' seems one essential point. InPUD has at least one moderator selected from faculty staff per board, and it is one single formal requirement to open a new board. This could be an important aspect for the building of trust (see sub-section expectations/trust above).

In the case of the InPUD-community the formal moderator was integrated into the community by an 'online role presence'. For example, "Mr. Miller, Advisor of Study Management" or "Mrs. Smith, Lecturer for Human–Computer-Interaction". These formal roles are visible when members communicate online. One student said: "When I can see who gives me the answer, a person from my faculty or a study manager, I guess this information is often a more valuable contribution than a student's answer" [quote of a computer science student 2003].

The visible presence of role names improved the ability to assess the quality of the information. The explicit formal role is seen as indicative of a contribution's quality, and used as such by new community members. The change of context (role names, description of what is (off-)topic, increase of informal moderating activities) increased the frequency of webpage requests, the number of student contributions, and affected the change in InPUD's structure.
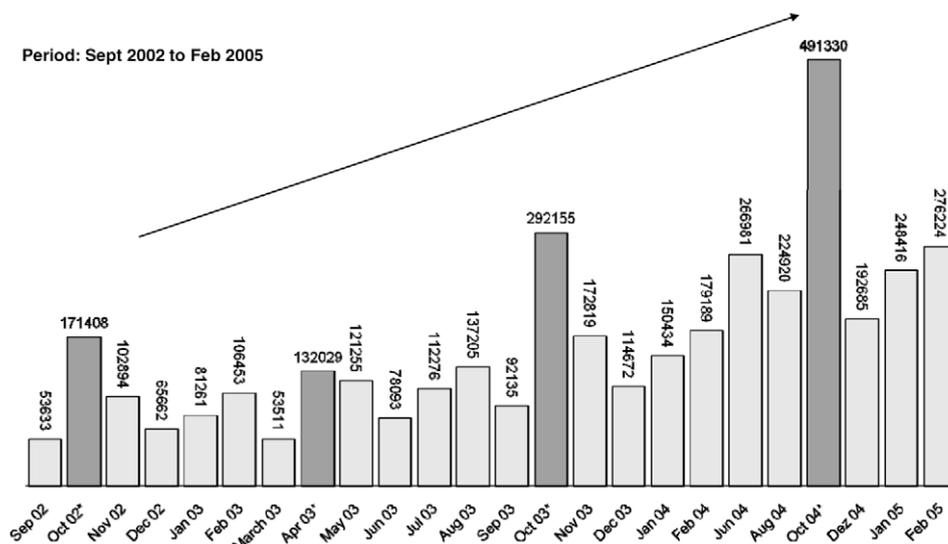

Fig. 7. Continuous flow to more usage (dark bars show beginning of a new semester).

During the stage of sustainable development in 2005–2006, more and more people from the faculty staff with formal roles (study managers, professors, lectures, academic staff, and people from the faculty office) became part of InPUD. In 2002, there were only five formal moderators online. This increased to 16 from 2003 to 2004, and between 2005 and 2006 this further increased to 45 new people from faculty staff becoming formal moderators. One student said: "InPUD has got more and more professors, lecturers, and tutors than 2 years ago, and they are more active than in 2003" [remark by a student in a computer science class about socio-technical systems in summer 2007. The discussion was about In-PUD as an example of a socio-technical system and was not a planned part of the research. However, it provided interesting insights into InPUD]. A new set of people appeared in the community (see Table 3).

This shift from only a few formal roles (e.g., formal moderator) to more formal roles (more people from faculty staff) can be explained by the increased adoption of InPUD from 2004 to 2008. Experts, in particular study counsellors, managers, lecturers and academic staff told us in 2002: "Software tools again and again – that's not the right way", "We have enough information on our websites", "A virtual community is not helpful", "It doesn't work". Even one professor said "It's more important to initiate face-to-face communication – before we cultivate a web-based thing". Apparently the views of the experts changed as the student moderation in the informal community proved its added value.

Obviously, the balance between community member's informal activities and formal roles changed. There are now more formal roles in InPUD than at its inception, which also indicates that the InPUD-community has evolved to a more formal organisation.

5. Discussion

This contribution has explored the development of a Socio-Technical Community (STC) in a university setting. The main research question was do roles as representatives for social structures within Socio-Technical Communities change over time, and if yes, what forms of social change will emerge? In particular, four characteristics of a role – as representative of the social change – were highlighted: changing positions/social relations, changing tasks/activities, changing expectations/trust and changing online interactions/role-playing.

5.1. Changing position/social relations

This aspect focused on whether positions and social relations change in STC's over time and if members only communicate fac-

Table 3
Shift of formal roles from the official organisation into the STC.

Formal roles	
Via contract/enrolment	Via membership/account
Official organisation	Socio-Technical Community
Faculty at a university	in its transformation phase
Examples	
Students	→ More regular members *than in its inception*
	→ More informal moderating activities
Faculty/Academic staff	→ More formal moderators
Study management advisors	→ Members with role names like 'study managers'
Teachers	→ More teachers
Administration officers	→ Director of dean's office
Dean for studies	
Manager for studies abroad	→ Manager for studies abroad

Note. In the transformation phase, more people in formal roles participate in the STC than at its inception.

tual information (aspect of content) and/or if one could observe indices about their relations to the others (aspect of position/relations). The empirical results confirmed the growth of the community over time and its change in general. The analysis also illustrated that the community consists of different types of social relations from its start in 2002 to 2008, since different types of communication – core, active or less active members – were related in different ways to one another over time. The results have provided qualitative hints that different types of ties occurred within the community. Some people even build strong ties, for example, community members who meet habitually at the same discussion board at the same time.

The answer to the first derived research question is as follows: community members communicate about their relationships and 'do' something to encourage and strengthen the level of relationships and personal ties. From the analysis, the following empirical based thesis can be derived: *there is a connection between the members' communication on the level of relationships, and the emergence of different types of ties within a Socio-Technical Community*. Further research could check whether more types of ties will occur within the community when more members of STC's communicate on the level of relationships.

5.2. Changing tasks/activities

The InPUD case illustrates that the tasks and activities changed. For example, the members began to employ new forms of communication that were labelled 'informal posting activities'. In the phases of sustainable development and its transformation, a lot of new members, who held formal roles from the official institution, appeared (especially moderating tasks by academic staff, e.g., teachers, study managers, administration officers). This can be called a new dimension for the STC's and InPUD in particular. It was not the appearance of a completely new role. The following empirical based thesis can be derived: *the more people with different formal roles come into the community – and changed the context – the more different, and complex types of formal tasks and activities emerge* (for instance, new topics on the discussion boards, women in computer science, new courses). In sum, social complexity increased.

5.3. Changing expectations/trust

With regard to whether a member's expectations regarding other users are accurate, the community members built trust in the first years and it can be described as the shift from pre-trust to trust. At least in the initial as well as growth phases, just a few formal moderators gave the InPUD-community the structure for facilitating trust. In addition, InPUD's connection with the official organisation (displayed by the university logo, legal information, contact field, and so forth) was obviously another factor that supported the trust-building process. In the phase of transformation, it seems that trust decreased, or at least is declining Apparently, the member's expectations and the community's activities could not match the same quality as in the earlier phases. Further research could investigate the following thesis: *as the usage increases within a STC (as a part of an organisation), more different types of communication and roles will be established over time, and with that, expectations and trust decrease*. In sum, an increase in usage, the number of community members and the different styles of communication appear to correlate with the trust-building process.

5.4. Changing online interactions/role-playing

The field study mainly focused on the moderator's role and its performance during online interaction. The analysis pointed out

that a changing context like 'show formal role names', and 'description of what is (off-)topic', also changed online interaction patterns in the STC. The change in context increased the number of formal moderators from the faculty staff. There are now more formal roles in InPUD than at its inception and a new set of people have appeared in InPUD. As the community has grown, formal moderation activities have become more prevalent. Further research could investigate the following thesis: *the shift from a few formal roles to an expanding number of formal roles can be explained by the increased adoption of a STC over time*. In sum, the results reveal that InPUD has been driven to a more formal organisation than an informal community (see Fig. 8).

It appears as if the faculty of the university (official institution) will 'assimilate' the community. Future developments will show whether InPUD is absorbed by the faculty or retains its informal character.

5.5. Implications

The InPUD-community building process clearly shows that a STC needs a sufficient balance between formal and informal structures. With regard to the sustainable development of the InPUD-community, it appears to have been important that the early adopters ensured that it would outlast the early stages and themselves. The increase of formal roles was one aspect for such a development, because it enhanced InPUD's future sustainability. Hence, a certain degree of formalisation is a prerequisite for sustainability. However, many formal roles – i.e., more formal than informal – might impede the continuing sustainability. Open issues for any community development and sustainability are, for example, (a) the degree of formalisation and (b) whether every informal community needs to go through some process of formalisation if it is to sustain itself. Further research is needed to establish whether the transition to more formal members is a typical one for STC's and 'regular' communities.

5.6. Limitations

Besides these new insights on how an informal community evolves into a formal one, it has to be mentioned that the study reflects a special type of online community: the online group emerged 'into' or as part of an existing institution. Thus, the results are limited to such social institutions (e.g., universities), non-profit organisations or companies. Communities on the Internet are often 'pure' ('leisure') communities without a connection to institutions. The findings are derived from a long-term field study and therefore not representative but typical, but they can spark off new ideas,

and innovative new theories about further visions of social structures of online knowledge sharing systems.

It is also important to reflect that the sample consisted of computer science students and computer scientists, who have a good knowledge of computers. This may have biased the results. Hence, it could be problematic to generalise the results to average users. However, a survey by Ebner, Schiefner, and Nagler (2008) showed that almost all students have the same technical equipment (90% have a laptop, 100% have a mobile phone). Also, a German study (Medienpädagogischer Forschungsverbund Südwest, 2007) found that a large percentage of young people (90%) know Wikipedia, YouTube© and some other communities (for private usage and leisure). However, merely 25% are active Wikipedia users. A brief survey of the computer science students in Dortmund (Hochschuldidaktisches Zentrum, 2008) gave similar results. To conclude, computer science students are not really different from other students – at least in their (non-)usage and experience of community-oriented ICT applications such as Wikipedia and YouTube©.

A third issue to consider is the reason for lurking. According to Preece et al. (2004), there are various reasons why people do not post, e.g., lack of motivation, no personal need, curiosity without exposure. One reason might be that InPUD's lurkers wanted to show their membership without any posting. Nevertheless, we do not have sufficient data to provide a definitive answer for lurking in the InPUD-community, and this will be a focus in further research work.

Finally, a drop-out study is scheduled (the survey was distributed in November 2008) to obtain an overview of how many people have left the community. Usually, they do not delete their accounts, even when they have left the university. This drop-out study will focus on the following questions: How many early adopters are still active today? What is the average duration of community membership – especially for students who are core members? and How many students finish their studies eventually?

6. Conclusion

This study revealed changes of social structures by social roles within Socio-Technical Communities (STC's) over time. The main conclusion is that STC's – as part of organisations – evolve from a less defined and rather informal structure to a more formal structure, which changes the balance between informal and formal activities. The InPUD-community evolved from an informal trust-based community with only a few formal roles to a STC where social mechanisms, and not the software architecture, support knowledge management processes.
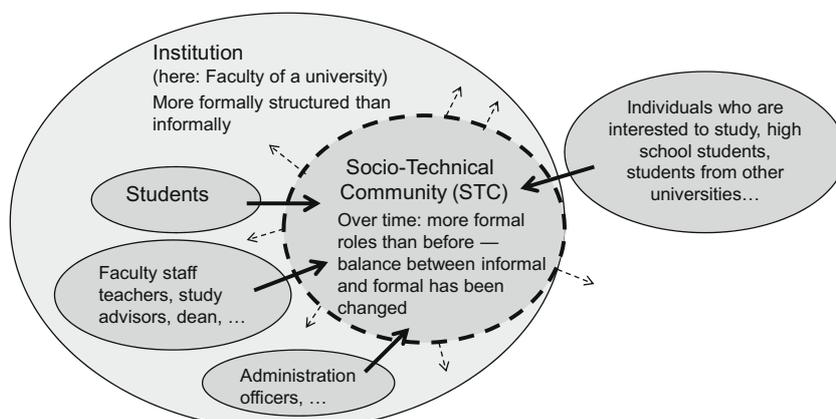

Fig. 8. Relationship of a STC to the official organisation over time – new balance between informal and formal structures.

Knowledge management studies reveal that online communities positively promote knowledge sharing in organisations. They initiate and enhance information exchange among many people in different departments (e.g., Lesser & Prusak, 1999; Wenger et al., 2002), which was confirmed in this present empirical study where the dynamic development of roles as representatives of social structures in a STC was focused. In contrast to online communities, a STC is part of an official organisation and enables a space for just-in-time communication. In this manner the STC reduces complexity and information overload from the official organisation, and this can be defined as an informal capability.

The general participation model of Wenger et al. (2002) includes different degrees of community participation – the core group, active members, peripheral users, outsiders and the role of a coordinator – and the field study showed that it is also valid for STC's in their early phases. However, there is also qualitative evidence that the structure of a STC changes over time. The quantitative increase of participation in InPUD signifies a continuing development of social relationships between its users, which is mirrored in the quantity and quality of their contributions. A clear willingness to be helpful to others was observed. Students developed an interest in the careers of others although they only knew them through InPUD. Due to the activities of its users, InPUD has become a continuously growing and helpful database for successfully organising and answering questions about computer science studies and study management. The In-PUD-community members built social structures through the use of the technical system. The InPUD case also shows a changing balance between informal activities and formal roles in STC's over time. For example, the InPUD-community created new social conventions (e.g., more activities of formal moderators), and more formal roles were included than in the earlier phases. In summary, the empirical aspects – development of informal roles, increase of formal roles, providing immediate support, and enabling an online presence – are characteristics of the 'developed social structure' of the InPUD-community.

From a DBR perspective the results of this study produced both practical educational interventions and theory generation including measurable theses that can be investigated in follow-up research. Further research could focus on the issue of community boundaries in relation to online networks and their effects on the Internet-based society. Do members of online communities build new social structures and 'social boundaries' or will they build a free-open network where everybody is able to participate without boundaries? Will system boundaries be dissolved or will they emerge on a higher level? Perhaps, the emergence of social structures and roles in online communities leads to new socio-technical boundaries (e.g., new members could be excluded; closed versus open systems), or the social dynamic leads to new socio-technical phenomena. Answers to these questions are required to further our understanding as we move from a social to a socio-technical educational system.

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