Interaction Patterns in Web-based Knowledge Communities: Two-Mode Network Approach

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Abstract: The importance of web-based knowledge communities (WKCs) in the 'network society' is growing. This trend is seen in many disciplines, like education, government, finance and other profit- and non-profit organisations. There is a need for understanding the development of these online communities in order to steer it and to affect the impact it has. In this research, we aimed to identify interaction patterns in these communities to visualize and understand community developments, and show the relevance of WKCs for the development of learning education. We conducted a content analysis and a network analysis on big social data to identify the patterns in two Facebook-groups which were focused on educational development. Analysis of interaction patterns enabled us to identify three interaction stages within WKCs in educational settings: introduction, evolution and maturity. In the first stage, participants mainly introduce themselves. In the second stage, one shares information and in the final stage, participants are more open to share their opinions. The study shows that our network analysis approach is appropriate to analyse and visualize the development of interaction patterns and the results could help us to steer communities effectively and efficiently.

1 INTRODUCTION

Individual and collective professionalization is already a hot topic for decades (e.g. Sheng and Yao, 2004; Windahl and Rosengren, 1978). As Chugh (2015) has indicated, there is – in our contemporary society – still an enormous need for ways to create and exchange tacit knowledge. One is thus still looking for the holy grail concerning the successful development of cooperative professional learning practices. Multiple initiatives were taken to stimulate this, some examples are communities of practice, teams, and physical meetings. But the technological advances has accelerated the developments in the way we communicate, collaborate and share our knowledge with others, this has resulted in a way of working which is more efficient and effective and which reaches a larger audience. The result is a dramatically growing number of professionals who share their resources, develop (new) working strategies, solve (existing) problems, and improve the individual-, the communal- and the organisational performance (Tseng and Kuo, 2014). Web-based knowledge communities (WKCs) exemplifies such continuous professional development mechanisms. A

WKC is "a community that allows individuals to seek and share knowledge through a website based on common interests" (Lin et al, 2007). Especially in educational institutions is the relevance of web-based knowledge communities recognized by for example teachers, pedagogics and instructional designers. These professionals use it to improve their own knowledge and skills, but also to realize a situation of continuous educational development. In order to put WKCs into perspective, we use the concept of learning education. This phenomenon is defined as "the learning landscape that facilitates the learning of all its members within open educational networks and continuously transforms itself in order to meet its strategic goals by using the latest online developments" (Vollenbroek et al, 2014). A learning landscape consists of different elements and professional learning practices, such as courses, conferences, regulations and the web-based knowledge communities.

In this study, we focus on the development of web-based knowledge communities. Since these online spots develop reasonable unstructured, it is important to visualize and analyse it. In this study, we make a first attempt by analysing interaction patterns

and visualizing it by the two-mode network approach. Interaction patterns represent the genre which activates individuals to perform in a certain manner.

This leads to the following research question which is central to this article: "What kind of interaction patterns describe the development of an online web-based knowledge community in an educational context?" An answer to this research question helps us to define the development of WKCs based on interaction patterns and can be used to monitor and steer the community development. Furthermore, the method of analysis and visualization of this development improves our methodological understanding of approaches to analyse and visualise these patterns.

2 MATERIAL AND METHODS

In this article, we analyse two specific professional development cases which are embodied as web-based knowledge communities. To describe these cases, we have decided to use a mixed evaluation method, which includes content analysis and network analysis (SNA). The Excel-plugin NodeXL is used to download and convert the data, and Gephi is used to visualize and analyse it. The first case embodies an interactive Facebook Group which belongs to a Massive Open Online Course (MOOC), due to privacy-issues we call this WKC: "Community of Learning Innovation". The second case is a Facebook Group for the professional linguistic development of individuals, we call this WKC: "Community of Linguistic Innovation". Initially the Community of Learning Innovation is aimed as a discussion environment for participants in the MOOC, this group has for that reason no formally assigned community leader. The Community of Linguistic Innovation has been started by a group of linguistic enthusiasts. An informal community leader takes the responsibility for stimulating the members to interact. The development of these public knowledge places offer a unique opportunity for all educators to learn and collaborate, despite their social and economic background.

As said, the download phase has been conducted with NodeXL, all likes and reactions on the Facebook posts in the two cases were downloaded during three periods described by Brown (2001) and Grossman et al (2001). These periods were operated as a starting point for the analysis of interaction patterns in the two cases. We made some adjustments to ensure that the phases better suit the short-term activities in these communities. Nevertheless, the first period (4 weeks)

which was downloaded is defined as the introduction phase. The central focus of this phase is the formation of a group identity, in which teachers form a pseudo-community with little interaction. The second phase concerns the evolution stage (2 weeks). In this stage, participants share thoughtful ideas. In the final stage, after a relatively longer period of time and involving intense association with others, one achieves camaraderie (6 weeks).

In the convert phase, the social development within these two cases was analysed using the concepts central to the genre-theory described in the work of Naaman et al (2010) to identify the interaction patterns within two online WKCs in Facebook, these interactions patterns were converted by using NodeXL. In the convert stage, the messages within the WKCs are coded with the genres described by Naaman et al (2010). The genres introduced were shown in Table 1.

Table 1: Genres.

Genre(s)	Example(s)
Statements / Random Thoughts	"It feels good to be appreciated…"
Opinions	"I would like to offer my heartfelt congratulations to…"
Information Sharing	"For those of you who missed <user>'s Webinar…"
Introduction	"Hello everyone. I am…"
Self-promotion	"Please, read my blog about…"
Me now	"I'm watching the webinar of…"
Question	"Can anyone recommend a nice, powerful, dynamic and innovative tool for presentations?"
Presence maintenance	"Good morning all…"
Anecdotes (me)	"My students mostly use Moodle as a …"
Anecdotes (others)	"<user> told me an example of…"

When encoding the Facebook-nodes, we used these genres as a base. For example, since Grossman, et al (2001) suggested that online WKCs evolve with a beginning phase where (new) members introduce themselves, we have added a genre in which one introduces them: 'introduction'. Ultimately, the inter-action patterns describe the development of WKCs visualized through the various types of interactions which occur.

In the visualization phase, we exported the converted data from NodeXL into Gephi in order to create relevant networks. These networks are visualized by following a two-mode network approach. A two-mode network is also often called an affiliation, bimodal or bipartite network. It means that the matrix may not represent a network with the same entities (Monge and Contractor, 2003). In the context of this research, this is a network were authors are connected to the genre of their interactions within Facebook. In this case, the rows denote individuals, the columns denote different types of posting (genres) and the cells are filled with the type of interaction (like or reaction). Broadly speaking, two basic approaches are available to analyse two-mode data. Borgatti and Halgin, (2011) distinguish the "conversion" approach and the "direct" approach. In the conversion approach visualizes one or both modes of the two-mode dataset are converted into two one-mode projections which are then analysed and separated. In the direct approach, which has been carried out in this study, both modes are analysed in a single graph. The colors in the graphs represent characteristics assigned to the nodes or edges, for example the genre or type of interaction. The size of the nodes represents the frequency a certain genre leads to an interaction.

Effectively identifying interaction patterns within networked structures was done by modularity analysis. Modularity is a measure that shows the density of edges inside groups as compared to edges between groups (Newman, 2006). Networks with a high modularity have dense connections between the nodes in a groups and sparse connections between the nodes in different groups. Modularity is often used as an optimization method for detecting community structures in networks, but in this study we use interaction patterns to define the dense groups of members in a WKC. Besides the modularity, we also use some descriptive measurements to describe the developments within the two cases.

3 RESULTS

We conducted a systematic content analysis and network analysis to define – in three different phases (beginning, evolution and maturity) – the underlying social interaction patterns in the two WKCs. The interaction patterns are operationalized by using the genres, described in the work of Naaman, Boase, and Lai, (2010), see Table 1 on the previous page for the genres and a realistic example from the Facebook-data. In the following paragraphs, we describe the resulting interaction patterns for each case in various phases.

3.1 Case 1

The first online web-based knowledge community we analysed in this research was the "Community of Learning Innovation" case. Community of Learning Innovation is a WKC that belongs to a Facebook group page of a Massive Open Online Course (MOOC). The goal of this MOOC is to teach educational stakeholders more about course-design by using educational technology in order to obtain extensive practical experience with online technologies and to develop a working understanding of incorporating successful online teaching strategies into the practices of educators. The lessons took place within Coursera, but the mutual knowledge exchange (and collaborative development of knowledge) largely took place on external social media platforms, such as Twitter and Facebook. The MOOC officially started in the last week of July 2014, but the interactions and introductions of the participants started two weeks earlier. The duration of the MOOC officially was eight weeks, but including the four weeks before the starting date, we analysed this case over twelve weeks.

The first four weeks form the beginning or sowing phase; during these four weeks, some participants introduced themselves and shared knowledge. The following two weeks forms the evolution phase; during these weeks, the network of participants grew. The last six weeks forms the maturity or harvesting stage; during this stage, the online web-based knowledge community professionalizes. This is the result of the course content of the MOOC and the increasing depth of conversations. However, during the three phases the number of co-likes decreased, while the number of co-comments increased (Figure 1).
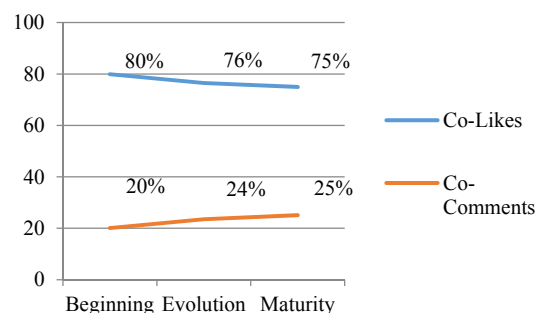

Figure 1: Level of Interactions (Case 1).

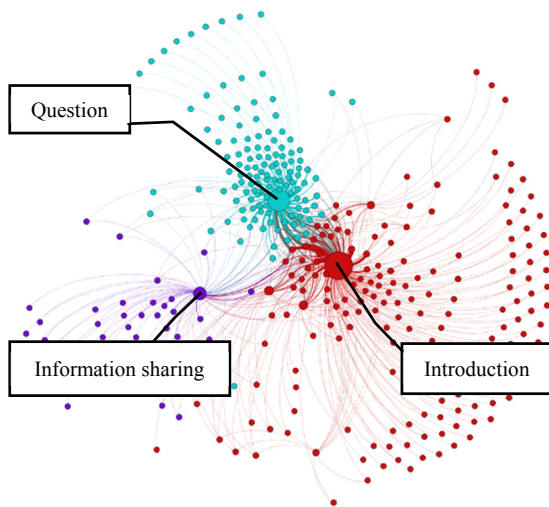### 3.1.1 Beginning Phase in Case 1

Figure 2: Beginning phase Case 1.

The main objective of the first community is to bring teachers together who want to improve their online teaching competencies. The following introdu-ctory text, derived from the course description, gives a brief explanation of the learning development the educators need to go through: "The overarching learning objective is to help existing educators to establish or improve their own online or blended teaching practices. As part of the course, there was the opportunity to develop an own understanding of effective online teaching practices and their relationship to the use of different technologies. The participants have also been encouraged to progressively design and reflect upon the own online learning activity, assessment or resource for use in the own class". The learning objectives described by the instructors show to what extent and in what areas the teachers develop themselves. They learn to establish and improve their own online or blended teaching practices; they learn to develop an understanding of effective online teaching practices, and their relationship to the use of different technologies. The Facebook community created for this MOOC started for socialization purposes. However, despite the lack of a specific goal, many people still actively participated in the community. A remarkable fact in the analysis is that the vast majority of interactions within the community consisted of participants 'liking' information, comments or questions instead of responding to the content. The sociogram (Figure 2) show the network within Facebook, in which the interactions were based on co-comments and co-likes

(initiator and responder). The results show an amount of 349 nodes and 573 edges. The genres of these interactions are related to questioning and individual introductions. The modularity within the community is 0.517 (51,7%), where a high modularity means more edges (interactions between actors) within the module than you expect by chance. Based on the analysis of the modularity, we can identify 14 modules of interaction. The majority of these interactions are co-likes (red edges), where members appreciate the contributions of others. The blue edges represent individual comments on certain genres.

3.1.2 Evolution Phase in Case 1

During the beginning phase, new members introduce themselves to the community. In the evolution phase, we see 283 nodes and 474 edges and a modularity of 0.335 (33.5%) with 5 clusters. The genres in this phase shift from mainly introducing one to sharing information and opinions. In total, the modularity is 0,335 (33,5%) and this resulted in a network of five clusters. The major cluster is the exchange of infor-mation, the second cluster represents the participants who share their opinions; the third cluster describes the number of questions from the participants; and the fourth cluster consists of introducing oneself, and therefore this fourth cluster strongly connects to the genre 'self-promotion'. In the final cluster in our study, participants gave anecdotes about themselves, to describe their best practices. In deeply conversa-tions (information sharing and giving opinions.
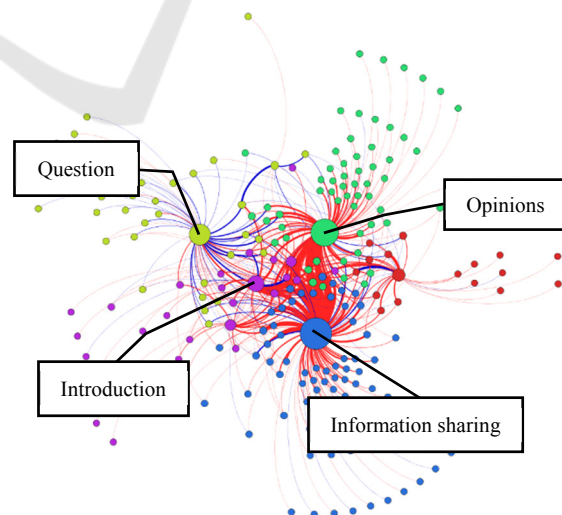

Figure 3: Evolution Phase Case 1.

3.1.3 Maturity Phase in Case 1

In the maturity phase, we see 446 nodes and 845 edges. The modularity in this phase is 0.276 (27,6%), with 6 clusters. The largest cluster or genre of the activities within the web-based knowledge community remains stable compared to the evolution phase: individuals within the community ask questions, share knowledge and information, and thank the teachers and other participants for their feedback and organization. Participants increasingly ask for help from their colleague-students instead of teachers, which underlines the benefits of a web-based knowledge community. The majority of interactions within the community are 'likes' (~ 75 per cent) and the remaining are comments, that are responses to questions.
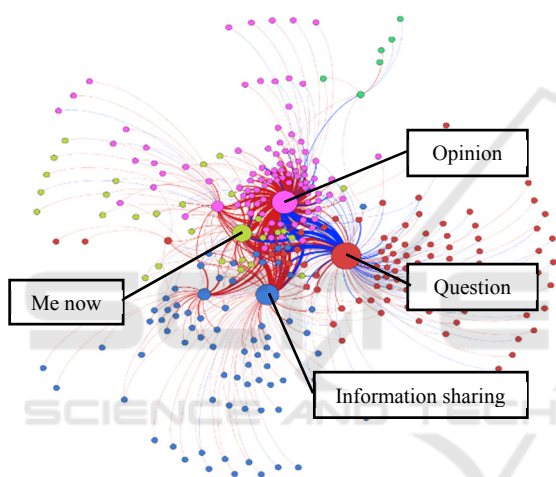

Figure 4: Maturity Phase Case 1.

3.2 Case 2

The Community of Linguistic Innovation is the second Facebook group we have analysed in this research. This group started in mid-September 2013. The intentions of the Facebook group were to researchers of English language who teach applied linguistics. The community aimed to provide a platform for English language professionals from around the world to share and exchange teaching and research information and ideas, despite their background. The ultimate goal is not only to improve the knowledge and skills on a micro-level (individuals), but essentially the improvement of skills and competences on a macro-level (teaching society). The content within the community is diverse, from topics such as the development of curricula and materials to language teaching methodology and classroom management. Figure 5 shows that the mode of interaction
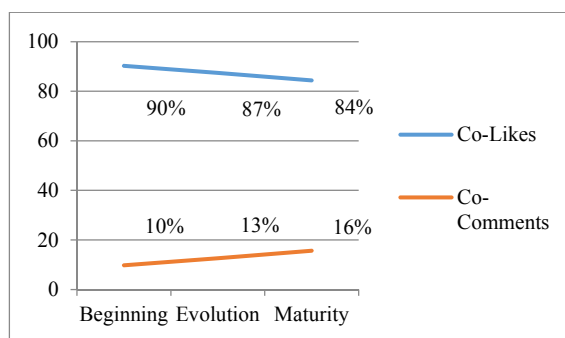

Figure 5: Level of Interactivity within Case 2.

over time increasingly shifts from the relatively passive 'liking' of content, to the more actively 'commenting' on content.

3.2.1 Beginning Phase in Case 2

The 'beginning' phase of the Community of Linguistic Innovation consisted in its first phase of 894 nodes and 1.574 edges in four weeks. The network mainly consisted of females (64,43%). At the start, the community leader introduced the formal goals for the community and made the participants aware of these goals. The community aims to provide a platform for English language teachers from around the world to communicate, share knowledge and collaborate in order to improve their own working practices, skills, effectiveness and/or competency. The results of the content analysis and social network analysis within Community of Linguistic Innovation clearly show that from its first moments, the introduction of the community has a special role, with
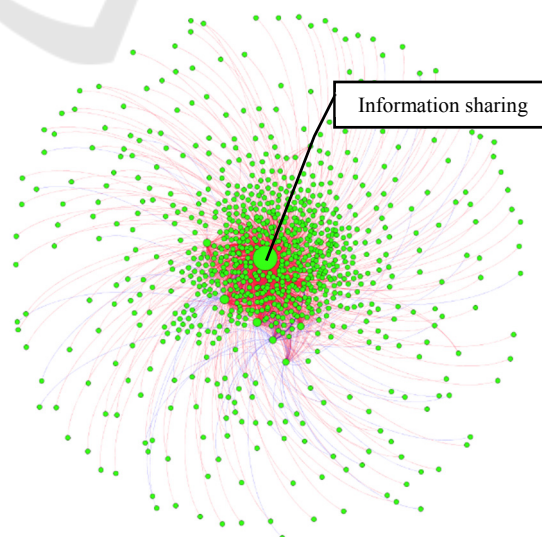

Figure 6: Beginning Phase Case 2.

185 interactions. However, within a few days, this picture completely changed. When the guidelines were clear and the participants introduced themselves, the participants considered it time to share their knowledge, to ask questions and share opinions, this is clearly visualized in Figure 6. The information sharing genre is a cluster that supplants the other clusters. The majority of the members (90,22 percent) within the community liked the exchange of knowledge with their colleagues. Almost 10 percent (9,78%) of the members commented on the posts, these are often questions, comments, articles or announcements.

3.2.2 Evolution Phase in Case 2

The 'evolution' phase of Case 2 consisted of 283 nodes and 474 edges in a period of two weeks. The interaction during these weeks has led to a modularity of 0.335 (33.5%). The majority of the members in the community shared, liked and otherwise reacted to knowledge within the online place. This is – when following the number of comments and 'likes' – the most appreciated form of interaction by the members. Another form of interaction; sharing opinions, and exchanging opinions strongly relates to information sharing. The code for the exchange of information with a 'personal touch' was 'opinion', because of that the information exchange is not completely objective. During the evolution phase an increase in co-comments can be identified, there was an increase from 9.78% to 12.58%, which show an increase of 2.80% in comparison to the beginning phase. This may indicate a growing sense of connectedness. The other 87.42 percent of the interactions are co-likes.
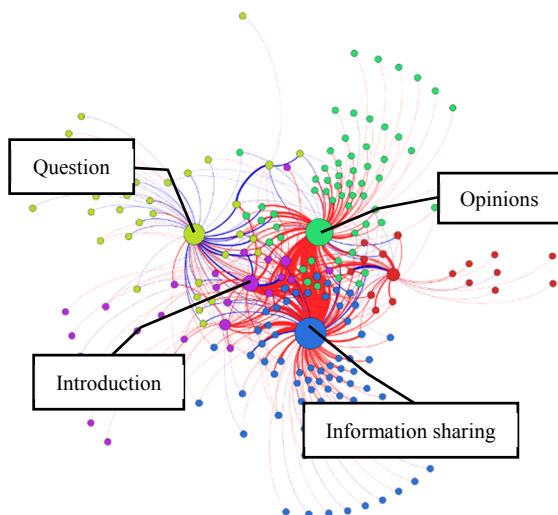

Figure 7: Evolution Phase Case 1.

3.2.3 Maturity Phase in Case 2

The 'maturity' phase of the Community of Linguistic Innovation consisted of 446 nodes and 845 edges after a period of analysis of five weeks. This resulted in six clusters with a modularity of 0.276 (27.6%). The majority of interactions in the maturity phase of the Community of Linguistic Innovation is represented in co-likes (84.38 percent), and we visualized this by the red edges in Figure 8. The major part of the participants decided to easily 'like' another's message. The remaining 15.62% are 'comments' on initial posts (blue edges). Again, we see an increase in the volume of comments rather than 'likes'. The interactions within the web-based knowledge community were mostly based on information sharing, expressing opinions and introducing new members. Since Community of Linguistic Innovation intended to be a continuous developing community, the introduction of new members is a continuous process. As the sharing of information and expressing of opinions increases, we can confirm that the individual's self-confidence to actively participate in the online environment is rapidly increasing after a certain period of time, whether this might be by liking other's reactions or posts or by commenting on others.
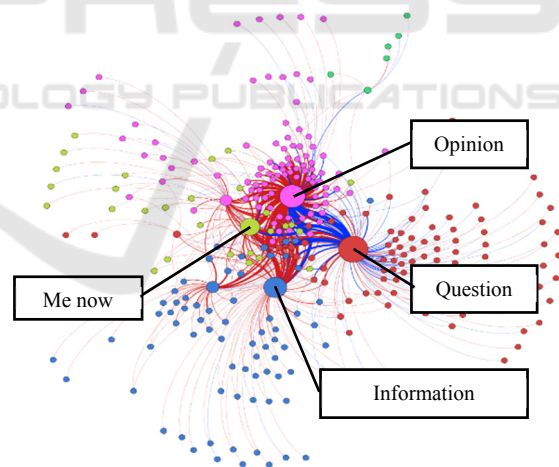

Figure 8: Maturity Phase Case 1.

4 DISCUSSION AND CONCLUSIONS

In this study, multiple interaction patterns were identified that represent the development of web-based knowledge communities. These interaction patterns were identified during three phases: the

introduction, the evolution and the maturity of the community. The resulting patterns provide insight into how WKCs evolve over time and provide insight into the increasing voluntary use of such WKCs. The patterns were identified by evaluating two WKCs in which innovative educational stakeholders interact with likeminded others with the common purpose to improve education. In this study we studied the development of these WKCs. A typical method for analysing and visualizing the development of such cases is by means of conventional methods available in statistical computer programs (for example SPSS and Amos). However, in this study we have opted for a method based on secondary data: social network analysis. We analysed and visualized the development of WKCs by using a two-mode network approach where the connectivity is represented in a relationship between individuals and the genre of conversations. The size of the nodes represent the weight of the nodes. The larger nodes embody the genre of interactions. The larger the nodes, the more relevant the genre. The colour of the relations characterize the type of interaction which can be a more passive 'like' or a more active 'comment'. The majority of likes were given when one introduces themselves, in case of opinions the number of comments increased.

The research question posed in the beginning of our study was: What kind of interaction patterns describe the development of an online web-based knowledge community in an educational context? To answer this research question, we have used the genre-theory introduced by Naaman et al (2010). Due to the differences in the two WKCs, we identified different interaction patterns. In the first case – Community of Learning Innovation – the participants all have a common interest: improving their online teaching competencies. In a MOOC, the participants have already learned the necessary skills to deliver online teaching, but in the WKC-environment discussions about the topic continued. In the second case – Community of Linguistic Innovation – individuals took part in an independent WKC with the central topic of 'improving English teaching'. In this WKC, the participants discussed the topic from various perspectives and at different levels of knowledge. Despite the large differences between the two WKCs, there are also some similarities. In both WKCs, we identified a remarkably similar development of phases. In the first phase, individuals introduced themselves. In the second phase, the individuals were more confident in sharing external information and in the third phase, individuals felt confident enough to share their opinions. In this phase, a form of friendship could be identified that was only minor in nature, but nonetheless, it is indicative of the success. The members dared to express their opinions openly– be it online and anonymously in the – communities. Since the size of the Community of Linguistic Innovation is continuously increasing, each new participant introduced themselves in contrast to the Community of Learning Innovation were the majority of members registered at the same time when the MOOC started. Especially the first members introduced themselves, but this trend gradually decreased.

To conclude, this research improves our knowledge about WKCs in general and gives insight into the sociological development of WKCs described with the genres labelled in the two-mode social graphs. The success of a WKC depends on the individual willingness to create a sense of group feeling (or community feeling). Each individual must feel confident to add relevance to the community before the individual and other members can benefit from it. One of the activities which stimulates the individuals willingness to share information is by first letting them introduce themselves to the other members. After a relatively short time frame, the members share the more formal information and after a couple of weeks they also share their opinions about the information others give and share more opinionated information/knowledge. Awareness of these stages and the related patterns increases the chance to successfully develop web-based knowledge communities.

One of the limitations in this study is the genre determination, since some interactions fit multiple genres. If for example someone asks "Do you also think that English should be the global language?", this statement can be judged as a question, but also as an opinion. In such cases, we have labelled it as a question. Since we have chosen to connect one genre per interaction. In upcoming studies we recommend to use multiple genres per interaction.

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