

Networked Grounded Theory

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The present paper demonstrates a research method combining Grounded Theory and Network Analysis for the inductive generation of a theory solely based on the empirical data being analyzed. This method was developed during my PhD research on the utilization of a virtual community (case study in Wikipedia) in formal Education institutions (tertiary or secondary education). The focus of this paper is on demonstrating the research method developed during this study. Networked Grounded Theory constitutes a remodeling of Grounded Theory and the rationale for the inclusion of Network Analysis techniques into the process of theory generation is explained. The software used and the steps followed are presented in detail in order to help other researchers to utilize the method or adapt it to meet their own research pursuits. Keywords: Grounded Theory, Network Analysis, Community Detection, Conceptual Network, ATLAS.ti, Gephi, Wikipedia in Education

Introduction

In their first book, *The Discovery of Grounded Theory* (Glaser & Strauss, 1967), Glaser and Strauss present a rigorous method for generating a theory, based solely on the empirical research data. The authors also argue that “in the past, too much emphasis has been put on verification of the existing theories” (Allen, 2010, p. 1606). According to Glaser and Strauss (1967), the key idea behind the grounded theory approach is the inductive development of a theory:

This is an inductive method of theory development. To make theoretical sense of so much diversity in his data, the analyst is forced to develop ideas on a level of generality higher in conceptual abstraction than the qualitative material being analyzed. (p. 114)

However, the authors’ principal aim of introducing Grounded Theory was “to stimulate other theorists to devise their own methods” for inductive theory development (Allen, 2010, p. 1609). In this direction, 46 years after the official introduction of Grounded Theory (GT) and following the introduction of many other GT versions, I demonstrate a method combining Grounded Theory and modern Network Analysis aiming at the inductive generation of a theory, based solely on the empirical data being analyzed. I used traditional Grounded Theory in the initial phase of the analysis, during the processes of open coding, constant comparison, theoretical sampling, and memo taking. The result of this initial phase was the generation of a network of interconnected codes. Subsequently, instead of using more traditional to grounded theory procedures (like axial or selective coding), I applied network analysis techniques (specifically visual outline algorithms and community detection algorithms) resulting in the detection of sub-networks and “communities” of codes in the overall graph of interconnected codes. I then used these emerging code communities as the conceptual building blocks for the construction of a theory. See Figure 1 for a visual presentation of the overall process of analysis.

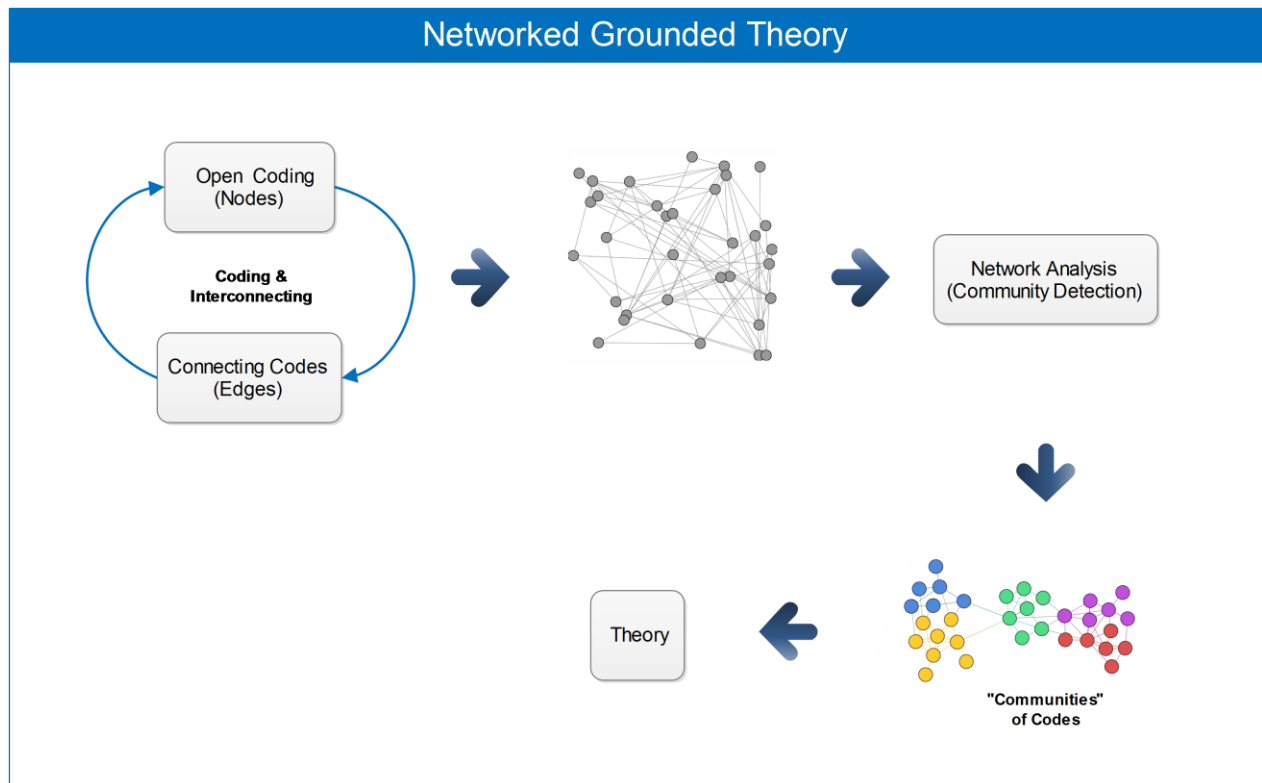


Figure 1. The Networked Grounded Theory Model. After open coding, constant comparison, theoretical sampling, and memo taking, codes are being interconnected forming a network graph. This graph is consequently analyzed using network analysis techniques to produce “communities” of codes which are used as the conceptual building blocks for the development of a theory.

From Grounded Theory to Networked Grounded Theory

I developed The Networked Grounded Theory method during my PhD research on the utilization of virtual communities (case study: Wikipedia) in formal educational settings (tertiary and secondary schools). In recent years many academics and secondary education teachers all over the world assigned editing Wikipedia articles to their students as part of their coursework. In August 2011, the Wikimedia Foundation realized the educational dynamic and potential of Wikipedia as a teaching tool and initiated a special program for promoting Wikipedia use to universities worldwide (Global Educational Program). My research method of choice for studying Wikipedia in Education was Grounded Theory for two main reasons. First, I was looking for a theory development method. The utilization of virtual communities in formal educational institutions is a new field, following the exponential growth of online communities. Wikipedia’s editors have created a thriving virtual community developed around the biggest crowdsourcing encyclopedic project in human history. Although many instructors assigned editing assignments to their students, there was no theory about what happens when a group of students interacts with a virtual group of people during a course assignment. I needed not to test an existing hypothesis; I needed a theory development tool. The second reason for choosing Grounded Theory was that I like the way qualitative researchers work. I like to immerse in the field (online or offline), I like to try to see through the eyes of the participants, to interview them, to understand them outside predefined categories and boxes.

Prior to my PhD studies I had not worked with Grounded Theory, so I became familiarized with the method while doing my research. I did not stick to a specific Grounded Theory tradition, although now I feel closer epistemologically to the Charmaz (2006) version,

because I was not quite sure about their differences and I did not know which GT version was the “best.” Not working from the beginning with a specific GT version increased my stress, being in a state of doubt all the time wondering whether I was doing something “wrong.” However, my choice of not sticking to a specific version, although stressful, also helped me to be quite open to differentiation and creativity. After performing open coding, constant comparison, theoretical sampling, memo taking, and interconnecting of codes, I was confronted with the network view, in ATLAS.ti CAQDAS software environment, shown in Figure 3. CAQDAS acronym stands for Computer-Aided Qualitative Data Analysis Software and as a term is stretching the fact that this kind of software tools are only used for aiding the process of qualitative analysis and not to actually analyze the empirical data (Frieze, 2012a). My first reaction when I faced this network graph in ATLAS.ti was: *“Oh my God! How can I cope with this mess?”* In my case the serendipity was that a month before I had experimented with Gephi network analysis software (Bastian, Heymann, & Jacomy, 2009) on analyzing Facebook social network graphs. In Facebook, persons are connected to each other through virtual friendships, forming complex social networks. Network analysis offers the methodology to analyze these social networks and discover meaningful patterns of organization. At this point I realized the idea of understanding and interpreting the “mess” of the interconnected codes in Figure 3 by using network analysis techniques.

Empirical Data Collection

The empirical data for my research were gathered primarily from interviews and focus group discussions with students and teachers participating in Wikipedia assignments, from online blog posts expressing students’, instructors’, and Wikipedians’ reflections on the topic and from Wikipedia’s community discussion pages. I systematically observed opinions, positions, and thoughts expressed by students, teachers, and Wikipedians (community members) involved in various educational activities in Wikipedia for a period of 2 years. Specifically, in this research I gathered empirical data from the following sources:

- Interviews with teachers and students conducted by me
- Interviews with teachers and students in publicly available internet sources
- Wikipedia’s community discussion pages
- Blog posts and online articles by students and teachers reflecting on their Wikipedia educational experience

Glaser and Strauss supported the simultaneous analysis of texts, publications, statistical reports, and interviews, as well as identifying the underlying concepts through the method of constant comparison (Hammond & Wellington, 2012). According to Glaser, *“all is data”* (Glaser, 2001, p. 145). This assumption makes Grounded Theory method particularly suitable for studying phenomena that evolve simultaneously offline and online and where empirical data are collected in both settings. Glaser argues that the researcher “need only see what incidents come his way as more ‘data’ to constantly compare, to generate concepts and to induce the patterns involved” (Glaser, 1998, p. 8). Charmaz argues that any information related to the phenomenon under study, everything that is perceived by the researcher at the evolution of the phenomenon, can be used as a source of empirical data (Charmaz, 2006). However, Charmaz points out that the quality and reliability of research rely on the quality of the empirical data. What makes the difference is the depth and the extent of the empirical data, their relationship with the research interests of the researcher, their appropriateness and adequacy to highlight the social processes: “a researcher can rarely come up with convincing cases of a limited set of empirical data” (Charmaz, 2006, p. 18).

Open Coding

My research began by coding the empirical data (open coding). Specialized software (ATLAS.ti) was used to facilitate the coding process. Initially, more than seventy codes were opened. Then through constant comparison, merging codes and rejecting irrelevant codes, the code set was reduced to 33 instances. According to Glaser and Strauss, the second stage in coding is the restriction of the initial set of coding categories (Glaser & Strauss, 1967). The immersion of the researcher in the social phenomenon he/she is studying and his/her increasing understanding of the developing theory, allows him/her to reduce the initial extended list of codes to a smaller set. Now the process of coding and analysis of empirical data can be more selective and focused (Glaser & Strauss, 1967). An extensive set of codes has the advantage of representing a lot of details and a wide spectrum of different dimensions of a phenomenon. The downside is that the encoding process becomes extremely difficult. In my study, during the initial coding phase I had to constantly cross check among more than 70 different codes to encode a given text segment. This task was extremely difficult. Finally, a set of 33 codes was formed and is shown in Table 1. In total, 1552 text segments were coded using this code set.

1	Aggressive Community Editors	18	Open Content Access
2	Assignment Topic Selection	19	Open Content Creation
3	Community Process	20	Policy Violation and Etiquette
4	Community Specific Strategies	21	Ruthless Editing Process
5	Contributing for Common Good	22	Size to be Manageable
6	Encouraged by Context	23	Students as Potential Community Members
7	Exposition to a Virtual Social Environment	24	Support & Workshops
8	Go Public	25	Supportive Community Members
9	Improve Research, Writing and Interaction Skills	26	Technical Difficulties - User Interface
10	Increasing Work Burden	27	They Gonna Mess It Up
11	Innovative Assignment	28	Valuable Content Added
12	Lack of Understanding Teaching Process	29	Voluntary Only
13	Need for Wiki Literate Organizers	30	We Don't Like Free Riders
14	Need for Wiki Literate Professors	31	Wikipedia Literacy
15	Need to be Organized	32	Wikipedia Validity
16	No Interaction with the Community	33	You Are Not Listening & Respecting Us
17	No Special Treatment to Students		

Table 1. A list of the final set of the 33 codes that were developed and used during the open coding process.

The Network of Codes

In the traditional (Glaserian) approach to Grounded Theory, the conceptual integration of the original codes is managed by grouping them into theoretical categories of a higher level of abstraction, a stage called theoretical coding (Punch, 2005). In the proposed approach, this abstraction is achieved through the formation and the subsequent analysis of a network of codes. In order to let this network emerge solely from the empirical data, the codes were interconnected logically with others at the base of their possible relation, during

the open coding phase, before knowing how these connections would shape the overall network graph. Whenever I observed a conceptual relation between any two codes, I drew an interconnecting line (or edge) between the corresponding nodes in the network view in the software environment and I added an accompanying memo to note the rationale for this connection. In a later phase, all these connecting edges were re-examined and new ones were created, based on the study of the co-occurrence table. This process resulted in the formation of a coding graph with the 33 codes as nodes and the connections between them as edges.

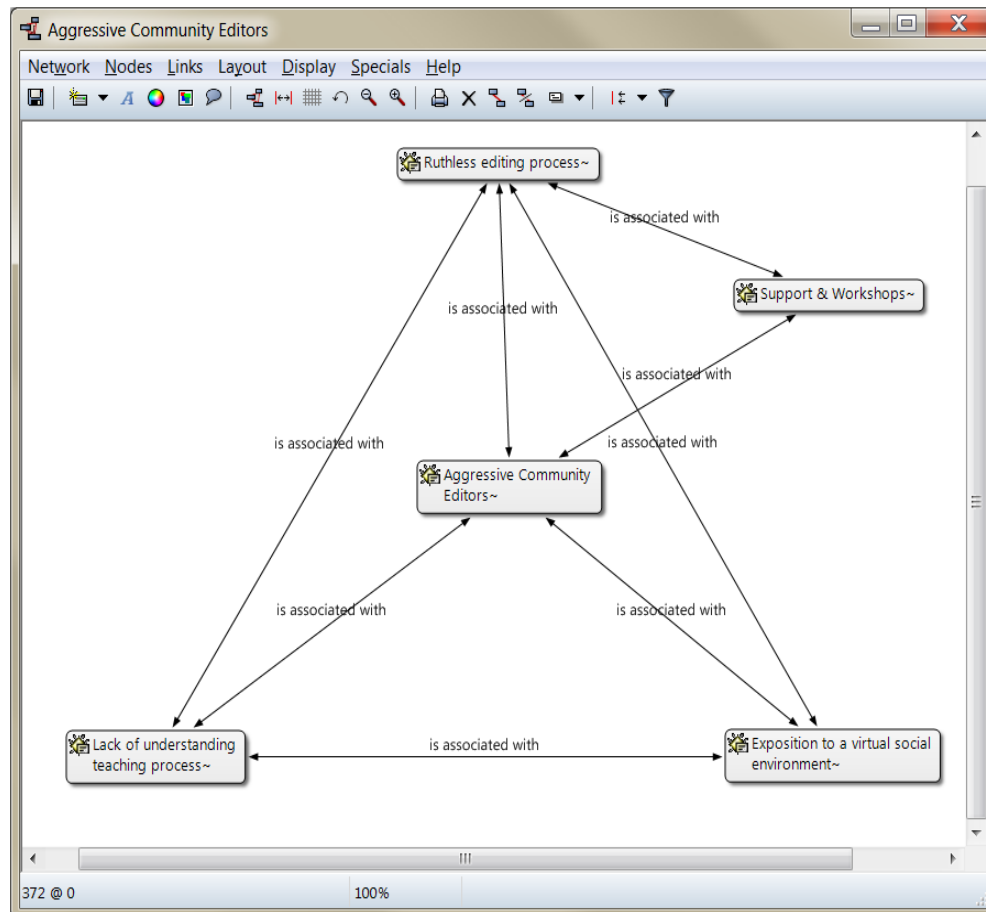


Figure 2. An example of a sub-network formed by interconnecting a specific code (Aggressive Community Editors) with others that are conceptually related (screenshot taken from ATLAS.ti).

The conceptual interconnection of codes is a necessary step in forming an overall network graph and the consequential detection of code “communities,” that is groups of codes more densely interconnected. Whenever the researcher identifies a logical connection to the data, this connection is entered into the CAQDAS software. The study of the co-occurrences of codes on the coded data segments is another way that can reveal possible conceptual connections between them (Namey, Guest, Thairu, & Johnson, 2008). This is because co-occurring codes are more likely to be linked conceptually, being alternative or differentiated views of the same core idea or concept. The supporting CAQDAS software (ATLAS.ti) offers a specific tool for identifying co-occurrences in empirical data, that is, the co-occurrence table (Friese, 2012b). By inspecting the normalized (scale 0 to 1) co-occurrence coefficients (c-coefficients) on this table (Friese, 2012b), the researcher is aided in recognizing patterns of co-occurring codes with the ability to directly inspect the corresponding text segments. In the event that the researcher considers two codes are related,

he/she draws an edge between them in the network view. The crucial point in this process is in determining the threshold, deciding whether two codes will be connected or not.

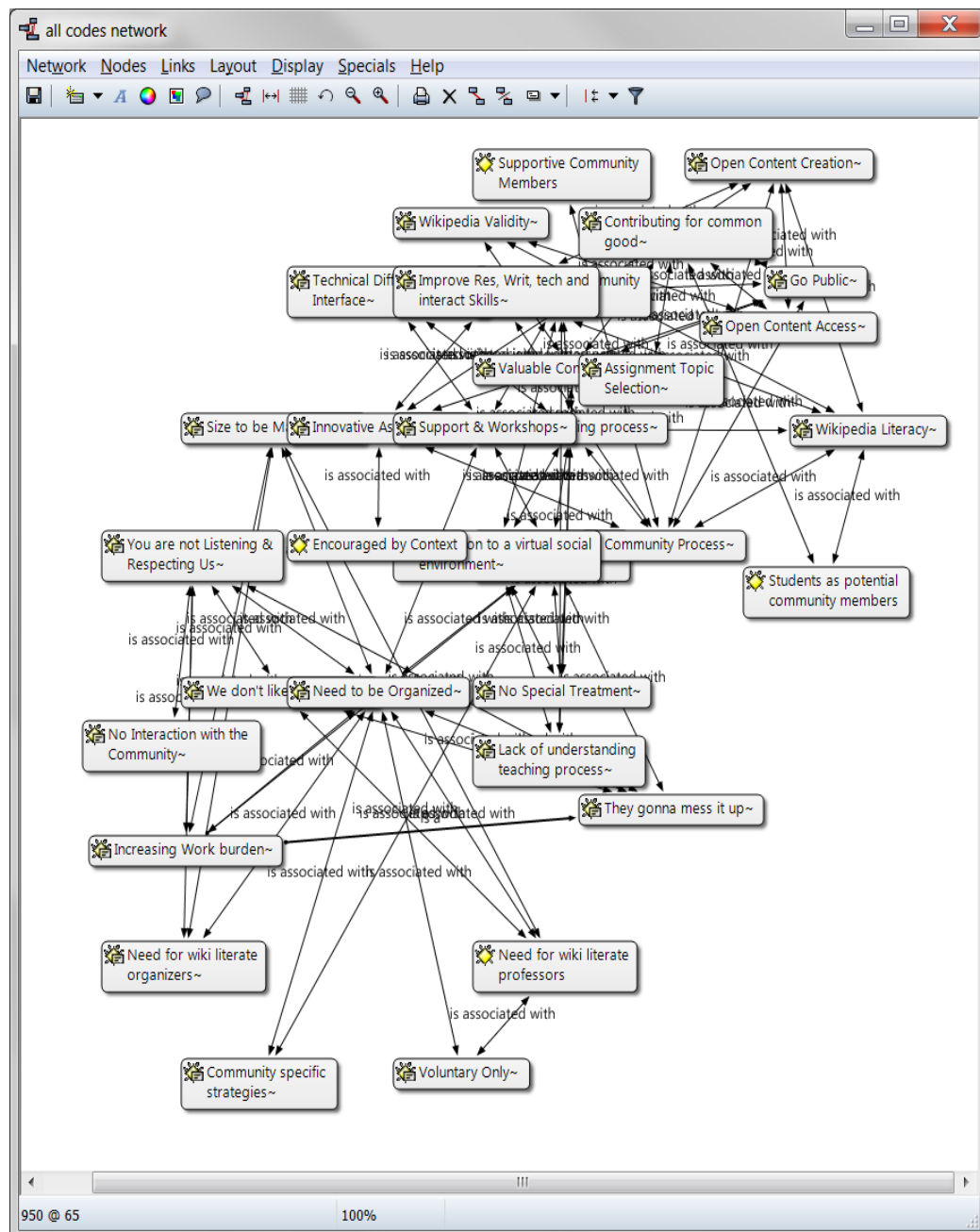


Figure 3. The overall network graph of the 33 nodes-codes and the interconnections-edges between them (screenshot taken from ATLAS.ti). In this network view any possible underlying organization or structure is not evident and atlas.ti does not offer any network analysis tools for helping the researcher in this direction.

A low threshold will lead to connecting all codes with each other. This approach reflects the idea that everything is ultimately connected to everything else but does not help the analysis process. The challenge is to find a more precise way of connecting codes, either directly or indirectly. On the other hand, a high threshold will lead to the total isolation of the codes and to the inability to form a useful network of codes. The process of interconnecting codes is a very demanding one: the researcher, having been immersed in the field and having direct knowledge of the phenomenon under study and by consulting the table of co-occurrences and

going back to the raw empirical data every time he/she has a doubt, constructs the connections between the codes. The result of this process is a sub-network view for each one of the 33 codes in the present study. Figure 2 illustrates a screenshot of a network for the code *Aggressive Community Editors*.

By interconnecting the codes that were developed during the open coding process, 33 unique sub-network views are formed. During this process the researcher does not know the possible final shape of the overall network, so he/she cannot manipulate the interconnections in order to produce a preconceived network graph. Each of these 33 networks (e.g., the network of Figure 2) is functioning as a constituting part of an overall complex network. However, each time two codes are connected, they are shaping not only the corresponding sub-network views but also the overall graph. The next stage in the investigation of the phenomenon is the study and analysis of the overall graph of the interconnected codes. In this graph, the nodes represent the 33 codes and the edges between them represent the way that these codes are conceptually connected. The overall network graph, as it appears in the software environment (ATLAS.ti), is shown in Figure 3. The overall graph is consisted of 33 nodes and 69 edges.

Network Analysis Software

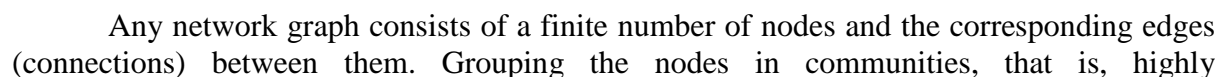
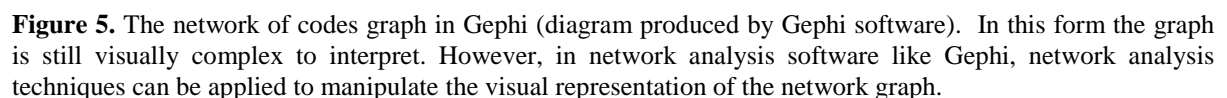
In the present form, it is quite difficult for a human observer to identify any possible underlying structure in the way the nodes are interconnected in Figure 3. This representation of the graph does not help us in understanding how codes are possibly organized in groups of a higher abstraction level. CAQDAS software (ATLAS.ti) does not offer network analysis tools (Frieze, 2012b). At this point in a more traditional Grounded Theory approach, the researcher, who has been immersed in the field systematically studying the phenomenon and acquiring a deep knowledge of the empirical data, develops the fundamental blocks of a theory, making every effort to ensure that the concepts are based solely on the empirical data and not on his/her own personal beliefs, preconceived views, or stereotypes. Today, we can take advantage of the methodological advances in the study of networks in order to analyze the network graph and determine the possible latent conceptual structure.

For the analysis of the network graph shown in Figure 3, I used Gephi software for network analysis (Bastian, Heymann, & Jacomy, 2009), in version 0.8.1-beta (<https://gephi.org>). Today there are many software tools available for analyzing networks with various advantages and shortcomings. I have chosen Gephi because it facilitates the intuitive and visual understanding of a network structure and organization. In addition to this, Gephi is free to use and is open source software (License: CDDL + GNU GPL 3). Open Source allows direct knowledge of the internal algorithms used in the software for which there are also scientific publications. According to the software website (gephi.org),

Gephi is a tool for people that have to explore and understand graphs. Like Photoshop but for data, the user interacts with the representation, manipulates the structures, shapes and colors to reveal hidden properties. The goal is to help data analysts to make hypothesis, intuitively discover patterns, and isolate structure singularities or faults during data sourcing. It is a complementary tool to traditional statistics, as visual thinking with interactive interfaces is now recognized to facilitate reasoning. This is a software for Exploratory Data Analysis, a paradigm appeared in the Visual Analytics field of research.

The first step in the analysis of the network graph illustrated in Figure 3 is the graph portage from ATLAS.ti to the Gephi environment. Unfortunately there is not yet an

Any network graph consists of a finite number of nodes and the corresponding edges (connections) between them. Grouping the nodes in communities, that is, highly



interconnected node clusters, could reveal a latent organization in conceptual blocks, the potential axial categories of a grounded theory under development. After entering the nodes and the edges in the environment of Gephi, the conceptual network of the 33 codes took the form shown in Figure 5. In this form, the graph is still visually complex as it was inside ATLAS.ti environment and still hard for the human observer to understand the potential underlying structure. However, in Gephi it is easy to apply network analysis techniques on such a graph.

Applying Network Analysis

In Gephi it is easy to have some preliminary network statistics. The graph is formed by 69 edges connecting 33 nodes. The average degree of the network is 4.182, meaning that each node is connected directly to an average of 4.182 other nodes (de Nooy, Mrvar, & Batagelj, 2011). The network diameter is 6. The diameter of a network is the shortest maximum distance that can be traversed between two nodes, in other words, the shortest path between the two more distant nodes (de Nooy et al., 2011). The average path distance, that is, the average distance between two network nodes (de Nooy et al., 2011), is 3.06. The calculation of some basic network statistics provides a general appreciation of the overall graph but is not enough to reveal a possible underlying structure. However, in Gephi it is possible to analyze further the network graph by applying an array of techniques for manipulating its visual representation.



Figure 6. The overall network of the 33 codes in Gephi after applying the imaging outline algorithm ForceAtlas2. Now an underlying structure appears on the network, with the codes grouped according to the relational connections between them in the overall network.

The first network analysis technique applied to this graph was an outline algorithm, specifically ForceAtlas2 (Jacomy, Heymann, Venturini, & Bastian, 2012). This algorithm

belongs to a class of imaging algorithms that operate through attraction-repulsion forces. The core principle of these algorithms is that the densely interconnected nodes are attracted to each other more and the less interconnected ones are repelled (Jacomy et al., 2012). The nodes are eventually grouped together in clusters based on the interconnections between them in the overall graph structure. By applying this visualization algorithm the codes network graph takes the form shown in Figure 6.

By merely applying the ForceAtlas2 outline algorithm, a visual structure in the graph appears. At this point the researcher, having researched the phenomenon systematically, can make some initial interpretations of the visualization, and make theoretical meaning of it. The next step to be taken is the systematic identification of conceptual clusters or the forming of axial categories in the terminology of Grounded Theory. For this purpose the researcher can apply an algorithm for detecting sub-networks in the overall network. The algorithms of this class are commonly called community detection algorithms, implying that in the case of social networks, these sub-networks correspond to social communities (groups of people more densely interconnected in comparison to out-members) (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). The detection of such communities is critical in discovering unknown functional sub-structures such as topics in information networks or virtual communities in online social networks (Blondel et al., 2008). In the case of a network of codes, these communities can be used as the conceptual building blocks of a theory under development. Moreover, these coding communities, the conceptual meta-nodes, remain interconnected revealing not only the constituent axial concepts of a theory, but also the way these concepts could operate in relation to each other. In this way, community algorithms can be used not only to facilitate a structural visualization of the developing theory but also to construct a functional model of it.

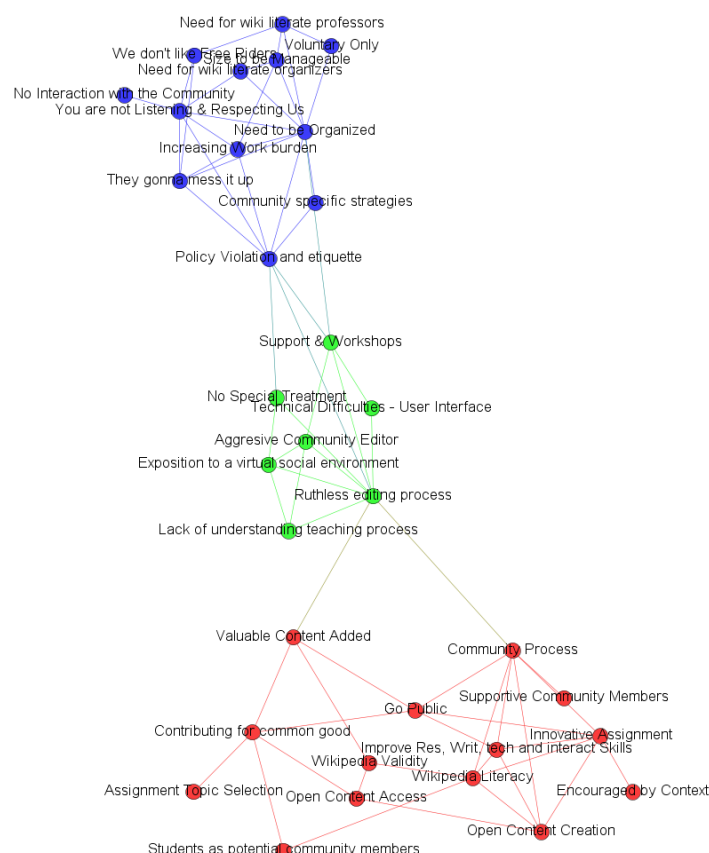


Figure 7. The network of codes after detecting communities in Gephi with resolution coefficient set to 1.0 (default value). The overall network is partitioned into three distinct communities shown in different colors.

The community detection method used in Gephi is based on an algorithm first proposed by Newman and Girvan with minor modifications to improve computational performance (Blondel et al., 2008). The sensitivity of the Gephi community detection algorithm can be adjusted using a resolution coefficient (Lambiotte, Delvenne, & Barahona, 2009). Increasing this resolution coefficient leads to detecting fewer and larger communities, while decreasing leads to detecting more and smaller clusters. The detected communities in Gephi are visualized by a different color. By applying the Gephi detection algorithm communities in the conceptual network of Figure 6 and by adjusting the resolution coefficient to 1.0 (default value), we can detect three distinct communities of codes. The modularity of the graph is calculated to 0.56. For each application of the algorithm a modularity parameter is computed (Blondel et al., 2008). This parameter can be used as a measure of the quality for the specific network partition. Values for the modularity over 0.4 are considered satisfactory and meaningful (Blondel et al., 2008). The three identified communities are shown in Figure 7 (colored by Gephi software).

Trying to identify even more subtle partitions in our graph we adjust the resolution coefficient to 0.8 (greater sensitivity) and we re-apply the community detection algorithm to our graph. The result is a network partition of four code communities with modularity value 0.555 (acceptable value). The resulting four communities are shown in Figure 8.

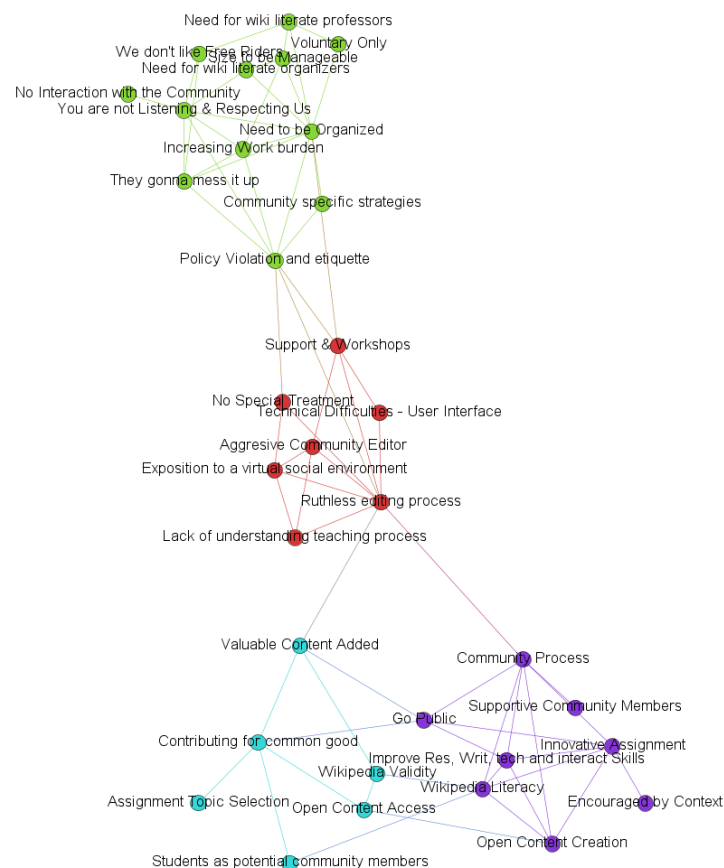


Figure 8. The network of codes after detecting communities in Gephi with resolution coefficient set to 0.8. The overall network is partitioned into four distinct communities shown in different colors.

In Figure 8, we observe that on the top of the visualization there is a fairly populous code group. For this reason we will continue the detection process for the possibility to identify more subtle communities in this specific area. We adjust the resolution coefficient to

0.6 (even greater sensitivity) and we re-apply the detection algorithm on the network graph. The result is the partitioning of the graph into five code communities with modularity value to 0.515 (acceptable value). The five identified code communities are shown in Figure 9.

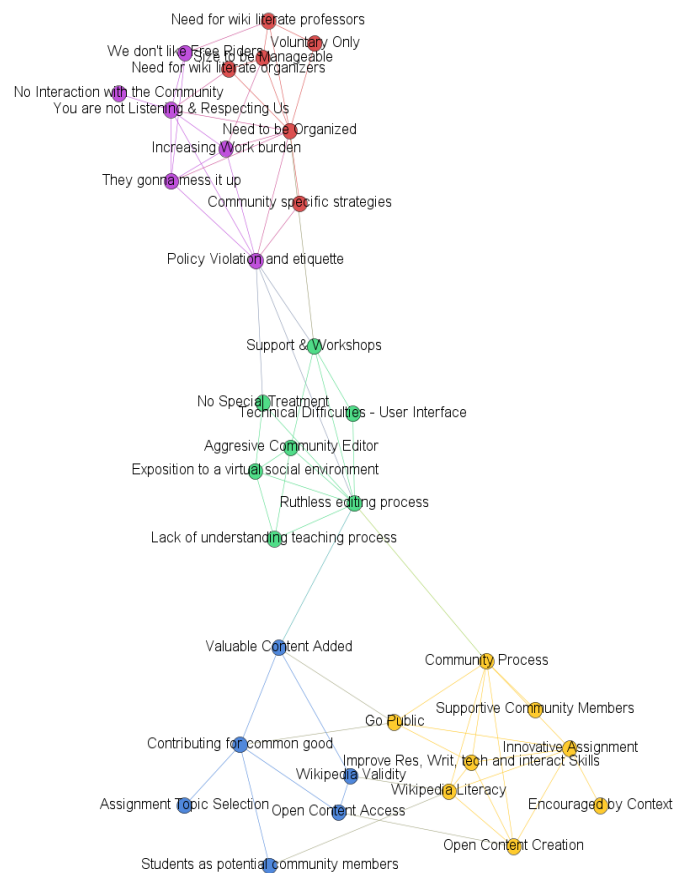


Figure 9. The network of codes after detecting communities in Gephi with resolution coefficient set to 0.6. The overall network is partitioned into five distinct communities shown in different colors.

By experimenting with smaller values for the resolution coefficient we identify more partitions but either without acceptable modularity values (<0.4) (Blondel et al., 2008) or without theoretical meaning for the empirical data this graph is representing. Partitioning the network of 33 codes into five interconnected code communities is judged sufficient in this specific research to reveal the constituent conceptual blocks of a theory under development in a higher level of abstraction.

Theory Development

The partitioning of the coding network, by applying community detection algorithm, into five code sub-networks reveals the potential conceptual blocks of a theory for the utilization of Wikipedia's community in Education. These conceptual blocks form a conceptual network, a network of interconnected meta-nodes. Each meta-node consists of all the first order codes found belonging to the same networked community. Figure 10 illustrates this conceptual network of meta-nodes and is produced by asking Gephi to visually group together first order code-nodes belonging to the same community.

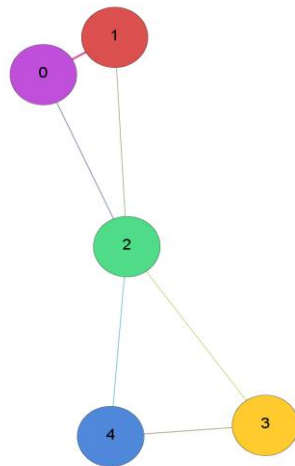


Figure 10. A conceptual network in Gephi after the grouping of the 33 nodes in meta-nodes, corresponding to the five detected code communities. Meta-nodes of the conceptual network constitute the conceptual blocks of the developing theory.

In Grounded Theory, “selective coding is the process of integrating and refining the theory” (Strauss & Corbin, 1998, p. 161). The researcher constructs a narrative that integrates the axial codes into a theoretical model, proposing cases and conditions (Creswell, 1998). The process of selective coding in Grounded Theory is essentially the process of building a narrative that interprets the phenomenon, through the selective interconnection of axial codes. In Figure 10, the meta-nodes, the conceptual blocks of the emerging theory can be interpreted by the researcher, labeled according to this interpretation and articulated into a proposed theory. In Figure 11, a paradigm of this interpretation and theory construction process is presented, corresponding to the empirical research data of my PhD study for Wikipedia in Education. Once a Grounded Theory for a social process is developed, it may be subjected to further tests and tweaking, using the same or a different research methodology (Creswell, 1998).

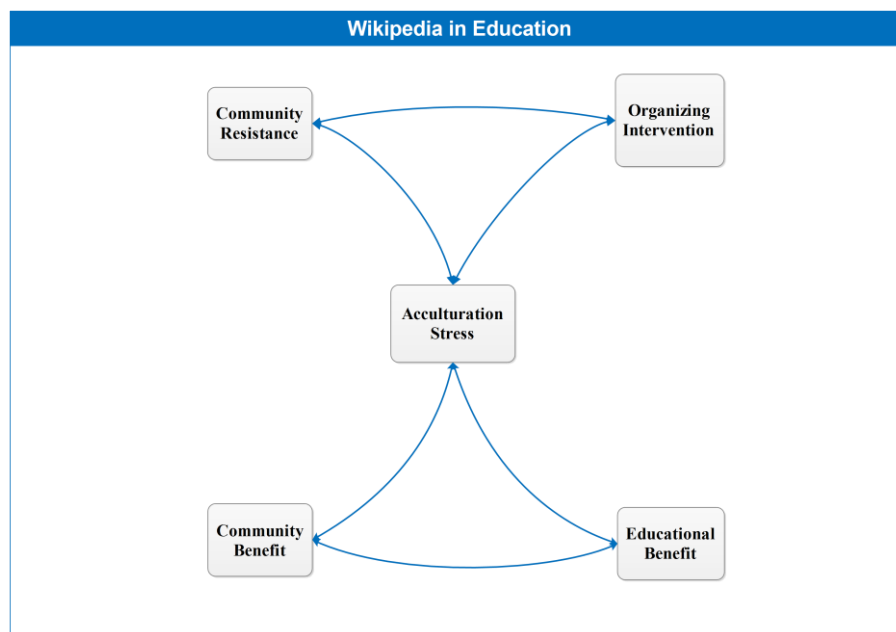


Figure 11. The Networked Grounded Theory model for utilizing Wikipedia community in Education. Community Resistance, Organization of Intervention, Community Benefit, Educational Benefit, and Acculturation Stress are the conceptual blocks of theory for interpreting the utilization of a virtual community in education as an acculturation process.

Traditional Glaserian approach to Grounded Theory requires avoiding literature review in the early stages of the method in order to avoid imposing predefined concepts on the empirical data and the theory to emerge solely from the data being analyzed (Glaser & Strauss, 1967). However, this requirement is not strictly enforced in newer versions of the method (Charmaz, 2006; Strauss & Corbin, 1998). In Networked Grounded Theory, a literature review can take place during the final stage of theory development following the network analysis and the formation of the conceptual network (like the one shown on Figure 10), in order to ensure not to enforce preconceived concepts on the data being analyzed. At this point the underlying graph structure has already been visualized, based on the application of standard network analysis techniques, and the researcher can safely interpret it and make meaning of it, without enforcing a preconceived graph shape.

Discussion

Networked Grounded Theory constitutes a methodological remodeling of Grounded Theory by introducing Network Analysis techniques in the process of developing the conceptual blocks of a theory based on the research data being analyzed. Visual manipulation of the codes graph helps the researcher to work more intuitively, by interpreting the visual representations of the graph according to his/her knowledge of the social phenomenon under study. At the same time the processes of network visualization and community detection are based solely on network analysis algorithms and the result is determined by the process of interconnecting first order codes, which is performed at an earlier stage, before the realization by the researcher of any possible network structure and shape. Thus, the emerging meta-nodes used as the conceptual building blocks of the developing theory and the connections between them are based solely on the empirical research data. The coding and the interconnection of codes into an integrated network graph, is performed during the early stages of Grounded Theory, before the researcher could have an overall conceptual interpretation of the phenomenon to force it upon the data. The literature review can take place after the formation of the conceptual network of Figure 10. Thus Networked Grounded Theory reduces the danger for the theory development to be led by potential stereotypes or predefined ideas of the researcher. At the same time the researcher is aided in the process of developing the theory, after having coded his research data and interconnected them into a network of interconnected codes, by applying standardized network analysis techniques.

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