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Network analysis and qualitative discourse analysis of a classroom group discussion

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ABSTRACT
A new methodology is proposed for qualitative discourse analysis (QDA) aimed at gaining enhanced insights into learning possibilities and indicators that arise during classroom group discussions. The constitution of this new methodology has two principle components: a discourse analysis approach that aims to identify the relationships between content and group dynamics; and a network analysis (NA) approach that uses the same data to identify meaning-related structural dynamics found in the data. The proposed methodology pairs these two components to create a supplementary iterative interchange that facilitates the attainment of greater analytic insights than are achievable by either of the two components individually. The critical aspects of the methodology are illustrated and discussed using real classroom data in ways that provide a procedural exemplar. The strengths and limitations of the proposed methodology are also discussed.

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Introduction

Student group-discussions present students with opportunities to engage with meaning-making that they cannot do alone through the simultaneously exploration of concepts, approaches and opinions with their peers in an accommodating environment (for example, see Fredlund, Airey, and Linder 2012). Thus, analysis of the learning potential from student group discussions has become an important feature of classroom research. The predominant methodological form underpinning such research efforts falls under the broad umbrella of discourse analysis. In discourse analysis, the function of language in terms of, for example, language above or beyond the sentence, or language as meaning in interaction, is analysed (Trappes-Lomax 2004). Good discourse analysis of group discussions is expected to capture both the form and content of the social interactions. Thus, analysis of group discussions needs to go beyond generating themes or categories from the content alone; the communicative meaning-related structural dynamics need to be included (Antaki et al. 2003). When examining the literature dealing with group discussion analysis, the majority of it is embedded in an approach that has many of the non-linear features of a ‘grounded theory approach’ (Glaser and Strauss 1967; Corbin and Strauss 1990). Typically, this involves verbatim transcriptions of the discourse followed by an iterative sorting of selected (coded) parts of the content to create concepts, characterizations or categories. The process continues until no new relationships or properties...
emerge in relation to the formation of new concepts, characterizations or categories (e.g. see Wood and Kroger 2000). It is here that a distinct weakness begins to reveal itself when it comes to analysing learning that emerges in classroom group discussions; the analysis becomes sourced in patterns of linearity for an activity system that has an aggregate that is non-linear. To address this challenge, a methodology that facilitates analysis of a complex system (see Mitchell 2009) of discourse is needed. This would facilitate treating a group discussion as an emergent learning system that is interconnected, adaptive, and self-organizing (see Davis and Sumara 2006). NA was chosen because its approach has strong conceptual and analytical links with non-linearity systems such as those found in complexity theory. In what follows, we propose and illustrate the incorporation of network theory into qualitative discourse analysis (QDA) to create such an orientated methodology.

We begin with a two-fold literature review and address the research genres that we used to develop our proposal. Then, an illustrative group discussion is used to present and exemplify the proposal, which characterizes an analytic approach that uses network analysis (NA) to effectively complement and supplement QDA of classroom group discussions that have intended emergent learning outcomes.

The illustrative data used was derived from actual recorded classroom group discussions dealing with the survival of Swedish wolves. The given analytic genre illustrates how an interplay between NA and QDA can lead to outcomes that would be extremely difficult, if not impossible, to attain from QDA on its own.

**Literature review**

This literature review section has two parts. The first part reviews research on learning through classroom group discussions that has drawn on QDA. The second part deals with those aspects that are most relevant to the methodology that we are proposing.

**Research on learning through classroom group discussions that has drawn on QDA**

One way to organize classroom discussions that support students’ active learning is to form small groups of students that together share and discuss their knowledge and ideas in order to address a task. Related examples involve students working in groups using ‘argumentation’ to help develop reasoning skills in the areas of data analysis, scientific understanding, and competencies in ethical and democratic discourses (e.g. see Driver, Newton, and Osborne 2000; Duschl and Osborne 2002), and socioscientific issues (SSI) (e.g. see Ratcliffe 1997; Kolstoe 2000). All of these examples have made use of discourse analysis approaches to explore students’ learning in group discussions. Such approaches have focused on either students’ social interactions or their development of defined reasoning skills. Despite the extensiveness of this research, little is known about the meaning-related structural dynamics of the kind of learning that group discussions can generate (e.g. see Howe and Abedin 2013). By structural dynamics, we mean the ordered ways in which central concepts are taken up and connected to each other in a group discussion.

The study of students’ development of understandings and reasoning skills has been performed using qualitative analyses in pre- and post-tests (Osborne, Erduran, and Simon 2004; Sadler and Zeidler 2005; Grace 2009; Zeidler et al. 2009). Such studies either compare parts of a discussion with a theoretical model to quantitate the level of sophistication of the discussion (Osborne, Erduran, and Simon 2004; Evagorou and Osborne 2013), or assess how students’ performance complies with targets, such as curricular content and social relations (Sadler and Zeidler 2005; Nielsen 2012). Drawing comparisons using a theoretical model or curricular content is to some degree limiting in the sense that data is forced into a premade structure, thus excluding aspects of contents and structures of the observed discussion. Another weakness is that the analyses of transcribed student discussions involve sorting extracts (‘chunks’) into categories that characterize various learning dynamics. In that process, group discussions are often treated as fragmented chunks (Mercer et al.
Our proposed way to deal with these weaknesses is to create a methodological approach that can facilitate deeper understandings. We do this by introducing a process that iteratively aligns QDA with NA in order to examine the meaning-related structural dynamics (in the way that we are presenting it) of classroom group discussions.

**Research on disciplinary learning that has drawn on NA**

Although NA has a long history of usage in the social sciences (see historical overview, Freeman 2004; Fredericks and Durland 2005), it is only recently that educational researchers have started including forms of NA to study students’ communicative actions (Shaffer et al. 2009; Enriquez 2010; Koponen and Pehkonen 2010; Bodin 2012; Bokhove 2018). The advantage to this approach is the multiplicity of connections that the analysis can uniquely establish, and where needed, work well with the temporal aspect of communication, i.e. the *progression* of communication networks. This is because a network can represent multiple connected entities as part of its analytic ability to bring to the fore relations *between* and *within* entities. Depending on the research tradition, these entities are referred to as *nodes*, *vertices* or *egos*, and the connections between these as *links*, *edges* or *arcs*.

We see NA as a process that can generate a range of different outcomes (called *products*). These emerge from NA as a function of the analytic focus (Costa et al. 2007). At the node level, the product is often a list that scores and ranks nodes in terms of their importance – their *centrality* (e.g. see Wasserman and Faust 1994). Here, a plethora of different measures exist, each designed to draw out different aspects of centrality. At the whole network level, the products of NA are meant to structurally characterize the whole network, such as its size (Faust 2006) or predictability (Sneppen, Trusina, and Rosvall 2005). *Community detection* is a large research field that is aimed at finding groups of nodes that can be said to belong together based on how they are connected. This is predominantly done via computer algorithms, which optimize a ‘quality function’ (Reichardt and Bornholdt 2006; Fortunato 2010). The result of community detection is a set of groups (often called communities or modules), which for some algorithms includes the set of connections between groups. Two examples that inform our work follow. After these, some further needed discussion on networks is given.

In a study on computer-based physics problem solving, Bodin (2012) interviewed students before and after an educational intervention. Bodin coded the transcribed data using a qualitative iterative sorting of interview transcripts in terms of what she called ‘epistemic elements’—statements expressing beliefs, knowledge or resources used in the learning situation (2012, 29). This step enabled Bodin to use the transcripts to create a network based on adjacency of these codes for ‘visualization and further investigation’ (2012, 29). Bodin used the *Infomap* community detection algorithm (Rosvall and Bergstrom 2008) to visually produce a map of the structural patterns in student reasoning both before and after the intervention.

Bruun (2012) used NA on student writings in physics by using *text mining pre-processing techniques* (Feldman and Sanger 2007) and creating networks of human written language (Masucci and Rodgers 2006) based on word adjacency. Here, *text mining pre-processing* refers to different kinds of operations performed on the original text, which allows for extracting information deemed useful. Building on this, the next key step is about finding significant connections between words that emerge from the remaining text. Author did this by creating a network of the words in the pre-processed text and performing NA on that network. This methodology can be seen as one of many possible ways of engaging with the emergent field of linguistic NA (Mehler et al. 2015).

**Linkage to text mining approaches in educational data mining**

Network-based analysis of texts from communications is a relatively recent development, which has been situated in text mining. Text mining for educational discourse has typically relied on a ‘bag-of-words’ approach, meaning that what is extracted from the texts of communications are unordered collections of words. For instance, Sherin (2013) provides an illustrative example of how such a
‘bag-of-words’ approach can be used to reveal clusters of words that co-occur in student utterances in clinical interviews. While this approach can provide information about the kinds of knowledge that are expressed by single students, it cannot provide information about the internal structure of each cluster nor about the relationships between clusters. Beyond the ‘bag-of-words’ type of methodology, our literature search has shown that student group discussions have hardly ever been analysed using either text mining or NA approaches.

However, what has emerged recently is a methodology that proposes moving away from a ‘bag-of-words’ methodology by creating an ‘order of words’ methodology (Aggarwal and Zhao 2013). Indurkhya (2015) argues for NA to become the methodological approach to use because it facilitates finding structural relationships in text mining. Aggarwal and Zhao (2013) point out that treating a text simply as a set of words will result in the removal of information about the structure in how words follow each other. They further argue that other approaches, such as ‘n-grams’ or ‘collocation processing’, to investigate the occurrence of sequences of words, will not yield information about the structure of the text as a whole. Aggarwal and Zhao’s proposed answer to this dilemma is to use an approach very much akin to Bruun’s (2012), and which is aligned with our proposal. They argue that the resulting networks become useful for classification, clustering and for ‘discovering significant textual patterns in the underlying network’ (Aggarwal and Zhao 2013, 11).

Combining QDA with NA could be considered as falling under the domain of mixed methods in educational research because mixed methods typically refer to integrating diverse insights that can be obtained by combining quantitative and qualitative methods (Creswell and Clark 2007). For example, Xiao and Witherspoon (2015) developed an iterative mixed method approach for analysing group decisions in terms of how discussions evolve over time as a function of topics. This is where our proposal goes further: it explicitly includes meaning-related structural dynamics.

The novel methodology we are proposing builds on the methodologies just described. Where we differ is in our focus in terms of making connections between meaning and structural aspects as they appear in the discussion. This stems from the need for a methodology that is more like the network analyses of Shaffer et al. (2009), Bodin (2012), and Bruun (2012).

The remainder of this article is an illustrative example of the methodology we propose. We have named the methodology Thematic Discourse Network Analysis (TDNA) because it is a methodology that iteratively combines discourse analysis with network analysis in order to produce connected themes in an iterative, reproducible, and transparent manner. First, we describe the overall methodology. The methodological approach that we propose here is a mixed one, where QDA contributes with qualitative elements and NA with qualitative as well as quantitative elements. The mixing happens in what we call the iterative TDNA alignment process. In this process, QDA and NA can be thought of as cogwheels that continuously interact. The end products of the process are QDA interpretations, which are linked to graphical network representations and a set of measures that gain their meaning in light of the QDA interpretations. We illustrate how to use the end product to ask new questions and how to address these questions in a further analysis and discussion of the illustrative data. Finally, we zoom out and discuss the overall methodology.

To follow the illustration and its associated iterations we recommend that close and continuous cross-referencing with the appendices takes place alongside the reading of the article.

**Illustrative example of the TDNA methodology**

In order to capture the complex nature of discussions derived from naturalistic data, we propose a new methodology named thematic discourse network analysis (TDNA).

In this section, we begin by giving a brief overview of the workflow in TDNA and then proceed to describe each process in more detail. The section that follows provides a concrete illustration of the kinds of interpretations, questions and further analysis this methodology generates and facilitates. A comprehensive description of the research setting for the illustrative example is given in Appendix A.
Overview and visualization of the methodology

In this proposal, TDNA brings together QDA with NA in an iterative framework. The overall process of TDNA is depicted in Figure 1, which can be used as a reference throughout the following description.

The recorded group discussion should be transcribed verbatim. Since ‘next-step’ decisions will be made during the text mining procedures that will follow, all words should be transcribed at this point (see Appendix B). Measures should be taken to ensure that the transcription only represents utterances of the student-group of interest. Then, what we call an initial QDA is performed (initial QDA in the sense that the QDA is iteratively refined in this methodology – see the section headed How to perform initial QDA). In parallel, the NA begins by subjecting the transcript to text mining pre-processing techniques (Feldman and Sanger 2007). Such techniques involve, for example, the removal of unwanted words (‘stop-word’ removal), treating a collection of words or phrases as a single term (‘stemming’ and ‘lemmatisation’), and deciding which sequences of letters and symbols will count as words in further analysis (‘tokenization’). In this stage, our methodology departs from standard text mining, since we rely on the QDA to inform us about these steps, as will be shown. From the pre-processed transcript, an initial network of interconnected words is created (Masucci and Rodgers 2006). The method of pre-processing and converting a transcript into such a network is illustrated in detail in Appendix B. When performing NA, centrality and whole network measures are calculated to aid interpretation. Next, TDNA uses community detection on the initial network to produce an uninterpreted initial map of the group discussion (see Figure 1). The purpose of using community detection is to reduce the complexity of the initial network while preserving the structure of the group discussion as captured by the network. The Infomap algorithm (Rosvall and Bergstrom 2008) does this on two levels; it groups together words into modules and finds connection between modules. Each module has an internal structure; it contains a subset of the original network consisting of the words that have been grouped together and their connections. Thus, Infomap creates a map of the discussion, which potentially allows for a bird’s-eye view of the group discussion. The results of the initial phase are initial products from QDA and initial views

Figure 1. The process of TDNA for analysing group discussion. The central part of the figure illustrates the overall process, while the surrounding boxes illustrate the different sub-processes.
products from NA. The products that emerge from QDA are different QDA interpretations describing themes (actualized perspectives on the issue) and discourse strategies (how actualized perspectives are discussed). The products that emerge from NA are a linguistic network, which represent the discussion, a map of the linguistic network and a set of network measures. The map of the linguistic network contains uncharacterized modules with an internal structure. Through the iterative alignment process of TDNA, the uncharacterized modules will eventually be characterized and interpreted as themes. At this point, the map is called a thematic map.

To be meaningful, both the internal structure of the emergent themes/modules and the relationships between them need to be characterized. Thus, the next step is a trial characterization of the would-be themes in the map to align these and the relationships between these in the map with the present existing QDA interpretation. It is through this alignment that themes emerge, for example, through re-interpretations, resulting in new discursive qualities or through formulating new text mining pre-processing rules. Here, a pre-processing rule should be understood as an action that is applied across the entire text, for example, removing a word, substituting one word for another, or joining two words. Thus, the aligning process enables interpretations that inform both types of analyses. Part of the alignment process is to create new rules for pre-processing. These rules may be, for example, new words to remove phrases that are treated as one word and words that are treated as synonymous. Applying these rules will result in changes made to the pre-processed transcript, which in turn will result in: (a) a new linguistic network; (b) a new map with modules to be characterized; and, (c) new values for network measures. Collectively we call this the intermediate network products, which are now used in the next step of the aligning process. Each iteration of the aligning process will produce an intermediate QDA interpretation plus an intermediate set of network products. The current intermediate QDA interpretations are used as a basis for new rules for pre-processing, while the current intermediate set of network products are used for further revision and refinement of the QDA. The alignment process, with subsequent reinterpretations, should be done until it does not seem to produce very different thematic maps or QDA revisions. The end result will be a final thematic map with an associated final QDA interpretation of the original transcript. This process is summed up in Figure 1.

In TDNA, the two analytical processes of performing QDA and NA are an integrated part of the whole workflow. TDNA not only identifies themes; the thematic map is imbued with a relational structure that constrains and, thus, helps interpretation.

**Details of the illustrative study’s operationalization of the TDNA methodology**

We now proceed with a detailed description of the initial and iterative alignment processes in TDNA. Each part is marked with a small icon that represents the relevant process as depicted in Figure 1. For this illustrative example of TDNA, we use a particular group discussion (see Appendix A).

**How to perform the initial NA and produce maps**
What we refer to as the ‘initial NA’ actually begins with four text-mining pre-processing steps: removing punctuation, converting every letter to lowercase, removing redundant white spaces, and removing frequently used words. These actions are done to remove noise and to emphasize words that are likely bearers of meaning in the discussion. It is important to note that this is only a starting point – in later iterations, QDA may suggest that some frequently used words need to be re-introduced because they are vital for understanding the meaning making as it is situated in the discussion. The negotiation of which words to remove during pre-processing and which words to keep is part of the interplay between QDA and NA that happens in the TDNA alignment process in our proposed methodology. To emphasize the importance of the removal of frequently used words, we show the effects of removing common words on networks and maps (see Figure 2A1-B2) as well as on the network measures (see Appendix D).

After the four initial pre-processing steps, the network is constructed; a directed link is established from Word A to Word B if Word B follows Word A in the pre-processed transcript (Masucci and Rodgers 2006; Bruun 2012; see also Appendix B). The next step is to apply the Infomap community detection algorithm (Rosvall and Bergstrom 2008) to make a map of the discussion in order to ‘both simplify and highlight the underlying structures and the relationships that they depict’ (Rosvall and Bergstrom 2008, 1). The MapEquation online software (Bohlin et al. 2014) can be used to create and visualize maps. TDNA may also use other parts of NA, for example:

- The number of unique words (nodes) and the number of unique connections (links). The number of nodes in our networks could be seen as the size of the pre-processed vocabulary used in the discussion while links represent how the discussion flowed. The pre-processed vocabulary is the unique words that remain after pre-processing and reflect the choices made during the TDNA alignment process.
- The number of mutual links; here, the bidirectional connections between words. Thus, they represent that these words have a dual semantic connection.
- PageRank (Brin and Page 2012), which is a measure of how central a node is in a network, is used to inspect the prominence of unique words.
- Distribution of connections – also called the degree distribution. Many networks, including semantic networks, can be fitted to a power-law distribution, meaning that most words are only used a few times, but a few words are used with a much higher frequency. In TDNA, a degree distribution with a sharp drop-off could signify a few central concepts driving the discussion, while a broader distribution might signify more complexity.
- Target entropy uses a simple model to measure the predictability of the flow in the discussion. For example, a string of words is completely predictable, because you always know where you came from and where you are going, just by looking at the network. This corresponds to low target entropy. However, with more interconnections between words, this certainty is lost from the network perspective, and the target entropy is non-zero. Very linear or very hierarchical networks tend to have low target entropy.

All these measures are formally explained in detail in Appendix D. For relevant measures, we also compare the networks with random variation, a procedure which is also explained in Appendix D. In TDNA, measures like those listed above serve as indicators of overall patterns, which when compared with the QDA interpretations can draw attention to themes and schemas that have been overlooked. Thus, the measures are continuously updated and used to gauge the validity and reliability of the network representation. Here, we give an overview of the results of the initial NA and map generation.

**Example of initial NA and map generation.** The initial map of the group discussion corresponded to the map shown in Figure 2, B2 (the module labels at this stage are generated by Infomap – they are the most prominent words in the module). Using this map, it seemed that the discussion was not as
one-dimensional as the initial broad characterization using QDA suggested (see below). This was visible, because the map had four distinct areas coupled together only by the central module labelled ‘actually, …’. An inspection of the structure of the modules suggested that some of the discussion was merely about reaching a solution that could prevent wolves from preying on reindeer, while other modules seemed to involve a more value-based part of the discussion. However, the word wolf was not very prominent, while the words than and actually were very prominent and did not add to the interpretation of modules as themes. The network measures suggested that the network contained more strings of nodes (see B1 in Figure 2) than could be randomly expected. Many unique words were used and were only tied together by a few much-used words (such as actually).

**How to perform the initial QDA**

To help convey the differences between a ‘traditional’ ‘QDA’ and QDA as it is implemented in TDNA, we now outline how QDA can be performed starting from the transcript. The transcribed
group discussion is divided into conversation units. A single unit can contain one or a few different views (perspectives) on the issue at hand. However, a unit should appear to be a distinct part in the sense that it ends as the conversation is exhausted; that is, it fades into murmur, takes a noticeable pause or is interrupted by a ‘new’ angle to the issue without an apparent connection to the previous utterance. The contents of a unit can be one turn, with or without agreements from other group members, or several turns produced by two or more group members. Typically, a new unit starts with a new angle to the task, either through a claim or as a question to the fellow students about an aspect or a position taken by any of the stakeholders. However, there are exceptions. For example, one student’s subsequent repeated claims were understood as an argumentation strategy and kept within one unit. Single turns containing rudimentary utterances regarding perspectives or facts that only occur once i.e. are not elaborated on by fellow students, should be omitted from the QDA as not belonging to the group discussion (providing that the research focus is on the development of the discussion in terms of students’ interactions).

To make a schema for doing the QDA, the starting point should be based on research questions. In the example presented here, the focus is on how students make meaning in an explorative discussion of an SSI task. The issue concerned wolves in Sweden and biodiversity, in which science-content knowledge as well as several perspectives provided a complex task for the students. Our interest in the students’ discussion concerned how significance was given to the different perspectives and how students’ interactions influenced the emergent learning in a group discussion.

In an explorative SSI discussion, it is important to consider all perspectives and weigh their significance against each other. Hence, making a schema for QDA means that, in the first step (1), sequences of conversation units are assigned to themes in which the students seemed to give particular significance to one perspective. For example, if the students during one or more subsequent units focus on the problem indigenous people have with wolves, the units are assembled into a theme, e.g. ‘indigenous people’. Units in which none of the perspectives are given precedence are to be brought together in an ‘indecisive’ theme. In the following two steps, the students’ discursive strategies are interpreted. In step 2, units within each theme are assigned to sub-themes according to how the students convey the values of the different perspectives. In this step, units with justifications are labelled as Facts, Personal (opinions and emotions), Values (morals and norms) and Authorities. In step 3, the manner in which values are conveyed (strategies) are labelled as either Claiming/persuading or Probing/nuancing.

The resulting analysis of the progression of a group discussion is displayed by listing the themes in chronological order (Detailed characterization of discussion constructed from the transcript; see Results). Group discussions are also broadly characterized, i.e. the whole picture, about what the group discussions seemed to accomplish (Broad characterization of discussion constructed from the transcript; see Results). This is done by interpreting the coded units as well as re-reading transcripts and listening to audio recordings to capture the students’ engagement in the task.

**Example of initial QDA**

**Broad characterization.** In general, the student-group seems to have one-dimensional discussions in which they try to create facts in terms of what everyone could find acceptable. These students show engagement in the process of dealing with the school task in the sense that their utterances are issue-oriented and they are active in the discussion. Their discussion is fact-driven and often explanatory, but the close-minded attitude leaves little room for further exploration of the issue. Although one of the students is dedicated to saving the Swedish wolf, the discussion is, in general, detached and impersonal.

**Detailed characterization.** As the discussion starts, one student claims that *the reindeer should be fenced in* (theme) for the purpose of protecting the indigenous people from economic losses. The focus is on facts regarding how to construct the fence in order to make the solution credible.
The idea is questioned due to the fact that too vast areas are needed (theme), since otherwise the pasture will be destroyed. The fencing in is also questioned on the factual grounds that, during winter, snowpack will facilitate wolves passing the fence. The discussion changes into an exchange of personal opinions and emotions concerning the significance of the wolves or the indigenous people’s survival. They contest the idea forwarded by the Minister of Environment that the wolf population in Sweden should be reduced to 180 animals to minimize the inbreeding problem (theme). This is justified by the assumption that it would make the problem worse. Next, one student probes whether the others remember that they had a wolf in their neighbourhood (theme) the year before. As this is actualized, the presence of a wolf is described with amazement. Then the group re-actualises the discussion on the size of the wolf population, and their suggestion, increasing the population, is justified because there is an inbreeding problem (theme). When one of the students tries to invoke an understanding for the indigenous people’s view (theme) of the situation, the students exchange personal opinions that pity the indigenous people who suffer economic losses. However, the student claiming that the reindeer should be fenced in (theme) again tries to persuade the group that this is the solution. Next, another student claims that since the reindeer are not fenced in, the indigenous people are to blame (theme) if a wolf attacks a reindeer. This is made even more persuasive with a claim that it is like having a bad harvest if you are a farmer.

**The TDNA alignment process**

![Diagram of the TDNA alignment process]

The alignment process involves changes to both the QDA interpretations and the products of the NA. The iterative process of revising the QDA interpretations feeds into the iterative process of revising the networks by formulating rules that are applied as pre-processing across the underlying transcript. First, we will discuss the types of rules and the reasons for the rules, using the example discussion to illustrate how new rules result in a new linguistic network and map. We will then give an example of how the NA helped change the QDA interpretations for the example discussion.

Throughout this example, we refer to Figure 2, which depicts three different stages of a linguistic network and map. For example, Figure 2, A1, depicts a linguistic network based on a transcript that has not been pre-processed except for removing punctuation, converting to lower
case and removing excess white space, and Figure 2, A2, shows the corresponding map generated by Infomap. Thus, Figure 2, A1 and A2, show the value of standard pre-processing. Words such as that become very central because they are used frequently, but the giant module named ‘that, …’ does not align well with QDA characterizations. Figure 2, B1 and B2, are examples of intermediate network products, while Figure 2, C1 and C2, are examples of final network products.

As the process proceeds, the meaning of links and nodes may change. For example, a non–pre-processed network (see Figure 2, A1) represents the flow of words as they were uttered. A final network and map may be seen more fruitfully to depict connections between words that act as bearers of meaning – semantic flow. Therefore, the structures found in intermediate maps (see Figure 2, A2 and B2) need to be continuously interpreted in light of the QDA interpretations, and changes are often needed. To illustrate how to proceed further by defining relevant new rules, we interpret the map presented in Figure 2, B2, as a representation of the semantic flow in the discussion. Each module in B2 represents a group of words with an internal structure. The map should be interpreted using several steps in which it is compared with the QDA. First, the names of the modules produced by the algorithm should be considered. The question to be posed is: do the names of the modules appear to represent themes, sub-themes or discursive strategies found in the QDA interpretation? In the example, one of the largest modules has than as a prominent word. In contrast, the QDA revealed that the discussion revolved around fences, reindeer, indigenous people and wolves. However, we can only see wolf as a small relatively unconnected module. Hence, it appears that the map is missing central parts of the discussion, as seen from the QDA. Subsequently, a new pre-processing rule is needed to align the map and the QDA interpretation to make themes, sub-themes and discursive strategies more conspicuous in the map.

Second, investigating internal structures of modules elucidates how and where themes, sub-themes and discursive strategies found in the QDA interpretation are embedded. Two examples illustrate this step. The first example is the word wolf, which was found to be less prominent than the QDA suggested. The rather small module ‘wolves, …’ in the map on Figure 2, B2, represented that word. In addition, the word wolf was found in the modules than and actually, also in Figure 2, B2. By choosing just one of the different grammatical forms of wolf to represent all grammatical forms, wolf would become more prominent. This could (and did) result in a more representative image of the discussion, as suggested by the QDA. Subsequently, modules previously containing wolf or its synonyms become reduced in size or may even disappear as modules. The second example is the module ‘something, …’ in Figure 2, B2. This module was found to contain the causal expression because. Since causal reasoning is interesting with regard to students’ justifications, we explored if like expressions were embedded in other modules. It appeared that causal reasoning could be made using a number of expressions. Hence, a rule that aggregates expressions for causal reasoning into one word (because) was needed to permit better representation of the justifications appearing in the QDA.

The examples above show that apparent misfits between maps and corresponding QDA interpretations can be the result of an over-abundance of words that represent little information relevant to the research question for the QDA, or of meaningful words – when present in many grammatical forms or as synonyms – becoming ‘diluted’. Hence, to proceed with the analysis, deliberate choices about what words and phrases best represent ideas need to be made. Since the rules will ultimately shape the final interpretations, it is important to keep track of the choices that get made for the pre-processing rules and why these choices have been made. Keeping track of these choices is also vital for the transparency and reproducibility of the methodology, and they also facilitate later scrutiny of the choices made (see Appendix E for a complete list of the rules used in this illustrative study). We found that these choices fall into different categories, which are explained next.
**Examples of revisions that affect products of NA.** Here, we give examples of different categories of choices to be made and use our example discussion to illustrate how these choices yielded useful NA products. There were many intermediate networks, some of which showed progress, while others did not seem to lead anywhere. In this illustrative example, we have chosen to show only networks (Figure 2) that showed clear progressions.

**Grammatical reductions.** For the purpose of this illustrative analysis it made sense to conserve the meaning of wolf as seen against how it used in the discussion. We did this by letting *wolf, wolves, the wolves, the wolf, the wolves*, wolves*, wolf’s, pack of wolves*, and wolf pack* all refer to the general idea of wolf. This insight came from the previous iterations of QDA and may not hold for other discussions or even analyses with other foci. One way to capture how the idea of wolf relates to other ideas in the discussion is to reduce these words by referring to wolf as just one word. This removes our ability to distinguish between words referring to wolf. What is gained is a representation of links to all words referring to wolf. Treating grammatical reductions as processes that hone the analysis to capture essential ideas behind words, leads to a network that connects essential ideas that emerged in the discussion. This manoeuvre can be seen as a choice that is informed by phenomenographic methodology (Sjöström and Dahlgren 2002). The condition for merging words here is whether the ‘super category’ wolf will result in a category that provides a faithful representation of all the words that are subsumed by it.

**Synonyms.** The argument for merging two different words into one is by and large the same as merging different forms of the word wolf into one form. If they refer to the same thing, it is meaningful to represent it as one word. Collecting more words into one might make a hitherto fragmented thematic map appear more coherent. This would then change our interpretation of the discussion. Figure 2, B2 and C2, shows this effect. B2 gives the impression of a fragmented discussion with at least four different parts, whereas C2 shows a network split in two – the top and the bottom. The two-way split was subsequently recognized in the QDA; after two dominant students tired of the discussion, others took over and shifted the discussion in a different direction. This is further discussed in the next subsection.

**Phrases.** In the iterative process, the products of the NA did not appear to display students’ justifications in alignment with QDA interpretations. The following illustrates how new text mining rules create better alignment with regards to this quality. The Swedish words *för* and *att* (similar to the English words *for* and *to*), used as prepositions, adverbs or conjunctions, are common words in spoken language. Hence, they are deleted in standard text mining pre-processing. However, the combination *för att* means *because*. *Because* is one important indicator for an argument (Schleppegrell 1996), and for that reason, we opted early on to treat the two words as a single word.
Slang, vocal pauses and interjections. Vocal pauses and interjections were removed because we saw them more as words that bind together other words that carry the meaning of an underlying concept. Slang words and expressions were treated as synonyms.

Indefinite pronouns. We found that the word *something* was connected to many disparate words. It is an example of a pronoun that is being used to make a generative phrase. *Something* is a word that gets used to refer to many things in a discussion. Such a word may be removed if its removal does not change the overall meaning of the themes and their relatedness in the discussion. This is what we have done in our illustrative example.

The quantitative results of these changes can be seen in Table 1. Changes to the pre-processed transcript resulted in changes to the PageRank of different words. For our example discussion, the changes are shown in Table 1 where, for example, the category *wolf* becomes the most prominent word in the network.

In the next section, we show how the initial QDA interpretation for our example was informed by the process of creating these maps.

Examples of revisions to the QDA interpretations. The alignment process showed that the initial QDA interpretation focused too much on the dominance of a single viewpoint (protect the Swedish wolves). The modular structure of the networks gave an indication that more viewpoints might be in play. Upon re-inspection of the transcript, a more fine-grained analysis showed that the single viewpoint was contested. However, the linear nature of the initial QDA interpretation made it difficult to achieve an overview of how often it was contested. In the emergent thematic map, the discussion appeared to weave around the thematic constructs (modules) that, in the end, were labelled: concern for wolf survival (*‘wolf,’* in Figure 2, C2), obstacle: #reindeer (*‘reindeer,’* ...), effective fences (*‘fences,’* ...), and difficulties (*‘difficult,’* ...). Graphically, the map revealed an emergent structure that was much less linear than the QDA interpretation projected. In particular, the connections between the modules revealed that the structure of the discussion was not nearly as one-sided as initially thought. Instead, the discussion displayed two distinct subsystems (there are no strong connections between the two sets of modules), which are visible in Figure 2, C2.

Table 1.

<table>
<thead>
<tr>
<th>Word</th>
<th>PageRank</th>
<th>Word</th>
<th>PageRank</th>
<th>Word</th>
<th>PageRank</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>it (that)</em></td>
<td>7.60%</td>
<td><em>fences</em></td>
<td>2.31%</td>
<td><em>wolf</em></td>
<td>4.15%</td>
</tr>
<tr>
<td><em>yes</em></td>
<td>3.52%</td>
<td><em>reindeer</em> (pl. form)</td>
<td>2.11%</td>
<td><em>reindeer</em> (sing. form)</td>
<td>2.09%</td>
</tr>
<tr>
<td><em>so</em></td>
<td>2.56%</td>
<td><em>precisely</em></td>
<td>2.00%</td>
<td><em>fences</em></td>
<td>2.71%</td>
</tr>
<tr>
<td><em>’ju’</em></td>
<td>2.17%</td>
<td><em>the wolves</em></td>
<td>1.92%</td>
<td><em>precisely</em></td>
<td>2.29%</td>
</tr>
<tr>
<td><em>is</em></td>
<td>1.95%</td>
<td><em>wolves</em></td>
<td>1.66%</td>
<td><em>area</em></td>
<td>1.79%</td>
</tr>
</tbody>
</table>
One subsystem centred on the largest module, ‘wolf’, being framed by intrinsic values, and the other centred on ‘reindeer,...’, being framed by obstacles arising from issues relating to effective fences and the number of reindeer. Hence, we added a tug-of-war between obstacles, being more concrete, and intrinsic values, being more abstract, to the characterization of the discussion. This process was a way to sensitize the analysis to different student voices; the variations in dialogical structure that can be modelled with NA is visually underpinned by the variations in the nested structure of the modules.

**The final products of the TDNA process**

![Diagram](image)

*Figure 3.* Left: Degree distribution of the final network of the group discussion. $k$ indicates the number of connections, while $P(k)$ is the probability of finding a word with that many connections in the network. Right: A picture of the linguistic network of the example discussion. The 10 largest nodes have been labelled with the corresponding words.

The TDNA aligning process can be stopped when the thematic map reflects the themes of the discussion, when relevant network measures reflect what can be expected from descriptions and interpretations from the QDA, and when changes to the pre-processing of transcripts suggested by QDA interpretations only generate very small changes to network products. The final products
are: a final linguistic network; final network measures; a final thematic map; and final broad and detailed characterizations of the discussion, which integrate the features in the network products with the original transcripts and recordings. While it is perhaps possible to apply the methodology by focusing mostly on the visual aspects of the produced networks and maps, important aspects may be lost if network measures are not considered. (For a fuller illustration of the network measures and how they change during the TDNA alignment process, see Appendix D). However, interpreting network measures in meaningful qualitative terms is not straightforward, so many interpretations are tentative. Even so, we do wish to initiate an ongoing effort to interpret network measures in this article. The next section illustrates how final products could be described.

**Final linguistic networks, network measures and thematic map.** The TDNA alignment process ended with the identification of 139 unique words (nodes) that were seen as bearers of meaning in the discussion. These nodes are connected with 209 links, 16 of which are mutual connections: wolf ↔ than, reindeer ↔ precisely, fence ↔ area, believe ↔ shovelling, snow ↔ blowing ↔ snow, quite ↔ big, year ↔ last. Sixteen mutual connections are significantly more than can be expected from random (Z = 3.0, based on 1,000 randomized versions of the network: N_{random} = 1,000). This may stem from different ways of employing the same words in the discussion. For example, than wolf and wolf than both signify a comparison. The distribution of the frequency of unique words (inserted in Figure 3) follows a pattern that is well known in the field of NA. The distribution can be fitted reasonably well to a power-law distribution (as opposed to a normal distribution), and the slope of the distribution is relatively high when compared to other linguistic networks in the literature (Solé et al. 2010). This indicates that a few words have relatively many connections, while most words are only used once. Taken together, these two measures may indicate a discussion that is narrowly focused on a few overarching trends. As mentioned before, the PageRank measure identifies prominent words in the discussion network (Table 1 and Table D5). Unsurprisingly, wolf, reindeer and fence rank high in this discussion. The prevalence of precisely and that (as in that thing) may signify a strong positioning of voices in this discussion, which supports the tug-of-war interpretation found in the previous section. Finally, the target entropy (see Table D5), which in the linguistic network can be understood as a measure of the possibilities for word combinations when following links in the network, is significantly lower for this network than randomly expected (target entropy = 0.22/node, Z = −2.2, N_{random} = 1,000). This is an indication of many linear pieces of discussion; a string of words would only yield one possible combination. This supports the interpretation that students were not engaged and adds that students did not put effort into trying to understand alternative perspectives; more engaged students might use words that other students had used in a previous argument, thus disrupting the strings found in the network.

**Final QDA interpretation. Broad characterization.** One dominant viewpoint in this group’s discussion appears to be related to finding a solution to protect the Swedish wolves. However, this viewpoint is repeatedly contested by one of the members. Thus, the discussion has two foci: one is solution-oriented and fact-driven; and the other is value-oriented and challenges the solution discussion. The focus on values has the potential to accommodate different points of view. It shows strong persuasive strategies by using words and phrases such as ‘because, … ’ and ‘in fact, … ’ to justify or strengthen premature solutions to save the wolf. A process that focused on dealing with the given task by making contributions that were issue-oriented, although directed towards finding a concrete solution, underpinned the style and strategy of ‘solution focus’. They appeared to freely ask for the opinions of others and express their own opinions, but the ‘solution focus’ left little room to explore other themes that emerged. Their discussion is, in general, detached and impersonal, as long as conflicting viewpoints are absent.

**Detailed characterization.** The first focus concerns how to make an increase in the number of wolves possible by fencing in the indigenous people’s reindeer (obstacle: #reindeer and effective...
The other concerns the value of wolves and the problem with inbreeding (concern for wolf survival). The group begins their discussion with the standpoint that the number of wolves should be increased. They do this on the grounds that wolves are ‘beautiful’, that they see no reason for Sweden to get EU fines for not taking actions to protect the Swedish wolf, and that they think (‘think, …’) the necessary increase in the number of wolves is prevented because of the risk that it would seem as though the indigenous people were discriminated against. From this standpoint, the protection of reindeer from wolves by building fences is suggested as the ultimate solution, which becomes the first focus of the discussion. They discuss the necessary actions for building effective fences, such as building them high enough and digging deep enough into the ground. However, soon the discussion unravels into a two-sided discussion with strong positioning. Further aspects concerning the difficulties with fences are discussed, but the perspective becomes locked. Little or no effort went into trying to understand alternative perspectives. The possibility of building effective fences is dismantled step-by-step with facts concerning anticipated difficulties with the amount of snow, how reindeer trampling can destroy the land when the snow melts (‘melt, …’), and the absurd amount of land area needed to fence in all reindeer. The fencing solution is finally abandoned, and the discussion is given a second focus. This concerns the value of wolves (concern for wolf survival) vs. the value of humans (intrinsic value of human), in which a tension as a fundamental societal problem becomes apparent. They keep up an unengaged discussion regarding the inbreeding problem, touching upon the possibility of importing wolves from Russia and the importance of having more than 300 wolves in Sweden to prevent the inbreeding from worsening. The value of wolves is given attention by recalling the presence of a wolf in their neighbourhood last year (‘year, …’). As the question regarding the understanding of the different sides in the conflict is raised, they claim to understand the indigenous people’s situation. However, the indigenous people are blamed for the situation. The fence solution is again advocated, and it is now justified on the grounds that the loose reindeer are the indigenous people’s fault and that they should be taking better care of their herds, i.e. keep them fenced in like cattle.

An example of using the final products of TDNA for further analysis and discussion

One of the compelling features of TDNA lies in the further work that is possible given the methodology. In particular, the TDNA opens up the data set for new kinds of questions and provides the tools to begin to address these questions. For the illustrative data set, this section elucidates the kinds of questions that may emerge and how our proposed TDNA provides the possibility to address them.

Emergent questions and addressing these questions

Having identified relevant themes and connections between themes using both NA and QDA, interesting new questions emerge through careful inspection of the resulting products. By considering in particular the thematic maps for a specific set of data, questions can be posed, and they can be answered by revisiting the original transcripts of the discussion.

For the illustrative example, we asked the following questions by inspecting the thematic map in Figure 4:

(1) What inferences can be drawn from the ‘tug-of-war subsystems’ being connected by the module difficulties with the flow going from effective fences towards concern for wolf survival?

(2) The arrow that represents the greatest flow is the one from year to concern for wolf survival. What further insight does this bring to the characterization of the discussion?

(3) There is a relatively large arrow pointing from the intrinsic value of human towards the concern for wolf survival. What kinds of values are the students giving to humans and do they compare them to those of wolves?
How we propose attending to these questions:

(1) The structure in the final thematic map interpreted as having ‘tug-of-war subsystems’ shows two distinct parts of the group discussion, i.e. the discussion is divided into two seemingly separate discussions. However, the arrows from effective fences towards concern for wolf survival rather indicate how the discussion turns, via difficulties, from a concrete solution towards two opposing values. The transcript, however, shows an extensive discussion wherein the fence solution is challenged, which leads to a rather condensed part where the opposing values, i.e. concern for wolf survival and intrinsic value of human, are included. This extensive discussion concealed the presence of two strongly positioned themes.

(2) The unidirectional arrow from year towards concern for wolf survival shows how relevant shared student experiences can flow into the discussion and have a dramatic presence. The transcript reveals how frequently the students refer to the year that a wolf was seen close to where they lived and, thus, how relevant this was to them.
The transcript shows that the challenge to the fence solution is ended by an argument advocating consideration of the indigenous people’s situation, i.e. **intrinsic value of human**. This is interpreted from the students having argued for the fence solution as a challenge to the **concern for wolf survival**. The different values were not discussed, an observation that aligns with low target entropy, indicating little interconnectedness between actualized perspectives. This can also be interpreted from the map where the arrows are directed towards **concern for wolf survival**. However, when referring back to the transcript, it becomes apparent that the separate subsystem, **concern for wolf survival**, could be interpreted as an underlying standpoint initially expressed through a number of arguments, including the fence solution, aimed at promoting and valuing the survival of the wolf.

**Discussion of the proposed methodology**

The raison d’être for the proposed methodology is that we identified inherent weaknesses with QDA in relation to analysing emergent learning in group discussions. In summary:

- Traditional group-work QDA can easily appear chaotic because utterances are often treated as fragmented chunks.
- A major challenge for QDA is to include meaning-related structural dynamics of group discussions.
- QDA that involves the comparison of transcripts with a theoretical model or curricular content potentially limits the subsequent interpretations.
- Approaches that divide discursive transcripts into ‘chunks’ during the analytical process can easily produce a fragmented image of the emergent learning in a group discussion.

We see these problems as embedded in the work processes of QDA, and if un-addressed, may seriously weaken the applicability of QDA as a methodological tool for the analysis of students’ group discussions. TDNA addresses these weaknesses by weaving together QDA with NA and can be used to reveal theoretically informed interdependent patterns that would otherwise have been very difficult to discern in a systematic way. We have illustrated this property with an illustrative example.

Having this summary as a discussion framing, we now turn to discussing different issues for the proposed TDNA methodology. First, we discuss the kind of theoretical knowledge that this methodology will likely underpin. Second, we discuss the non-trivial matter of scientific rigour when combining QDA and NA. Even though NA has strong links to both social and natural science traditions, it is often portrayed as warranting constructs of validity, reproducibility, generalisability and objectivity as benchmarks for scientific rigour. Lincoln and Guba (1985) argued that qualitative methodologies do not warrant these benchmarks. Instead, they argued for credibility, dependability, transferability and confirmability. We find that when mixing QDA and NA, these parallel categories need to be addressed to more fully appreciate the results of the methodology. Third, we address some of the strengths, limitations and future promises of the method.

**Characterization of knowledge produced**

The key point of TDNA is to treat discussion data as relational, rather than a chronological sequence of discursive themes. Furthermore, the relational systems that we have used for our illustration seem to be complex systems in the sense that larger scale structures emerge from local interactions. The viewpoint that these systems are complex can be used to characterize the knowledge produced. First, we must expect that the entities we study – here, ideas/concepts as represented by words – gain their significance and meaning by their connections to other entities. Second, we achieve a structural and static picture of the dynamics of the discussion. It is a bird’s-eye view that reveals patterns, which are
not otherwise readily available, for example, the tug-of-war system in our example. The tension between the chronological view of QDA and the probabilistic view of NA can be overcome by looking for patterns in the thematic map and then checking them in the QDA interpretations and even in the original transcript. In addition, the tension is fruitful, because when diving into the transcript, it is as though we are standing in the network, unable to see very far beyond the nearest neighbour, i.e. the next unit in the QDA interpretation or the next turn in the transcript. Interestingly, the problem of navigating networks is an area of research in network physics. For example, Axelsen et al. (2006) used a landscape metaphor to characterize networks as, for example, having mountains (nodes with many connections) and valleys (nodes with few connections), or being smooth or rough. They related these features to the function of the network. We find the landscape metaphor intriguing, because it highlights that a thematic map is analogous to a cartographer’s map. If a network is like a landscape, then the thematic map should capture central features that allow us to navigate the landscape. The map provides the means to navigate to the interesting parts, which can only be fully appreciated and understood through full immersion (revisiting the transcripts).

Along the way towards creating a viable thematic map – through the alignment process – the meaning and status of words may change. By systematically making and implementing linguistic choices, we are affecting how words are related. If a word in the final iteration can be taken as representing a concept, then the network represents how concepts are connected. Recall the example of collapsing all grammatical forms of the word wolf to just one. By doing this, we gained access to the variations in semantic connections to and from the category wolf and made it visible in the network.

### Possible issues of scientific rigour

From a quantitative reliability point of view (Golafshani 2003), it can be asked whether the same maps would be created if the same algorithm gets used to map the same network. We have not focused on this issue in this article, but the proposed algorithm has been shown to produce consistent results (Brewe, Bruun, and Bearden 2016). From a qualitative point of view, the issue of reliability is much more controversial. Obviously, one cannot reproduce the setting to see if the same discussion map would be produced. Yet, what this method affords is a tool for making an inquiry audit (Lincoln and Guba 1985) which can increase the dependability of the interpretations that we make. For example, making a choice of grammatically reducing the number of noun forms of wolf in Swedish to just wolf produced networks and maps of discussions that were immediately recognized by the three authors as being more closely aligned with the discussions. Moreover, interpretations of quantitative measures for each group was seen to align more and more with interpretations of the qualitative analysis.

There is also the possible issue of credibility inherent to TDNA, which is connected to social dynamics and speech patterns. For example, a person may have views that are at odds with the others in the group, and thus spend many words trying to convince the others of the value of their viewpoint. The others on the other hand, may not feel the need to use as many words. Another example is a person who uses many words to convey a message as opposed to people who do not. If researchers focus too much on the NA-part of TDNA, then this may skew interpretations of the discussion towards giving too much weight to one person’s views. A network may show many of the words that the ‘odd-one-out’ uttered. However, this is exactly why TDNA prescribes a revisiting of the transcripts in order to revise both QDA and NA interpretations.

TDNA introduces reproducibility into QDA in the sense that given the transcripts and the choices for pre-processing that we made, everybody else should arrive at the same final networks and the same structure of the final thematic map. In this sense, we also reduce the subjectivity of the qualitative interpretation and the potential to generalize to a larger set of discussions. Hence, once there is an agreed upon a set of rules, they can be applied equally over an entire corpus of text. At the same time, since meaning can be very contextually based, one has to bear in mind that this comes with a
risk of losing aspects of meaning. However, since QDA approaches are normally used with a variety of analytic frameworks that stretch from the linguistic to social interactional domains (Trappes-Lomax 2004), the choice of framing inevitably will bring a mixture of gains and losses. And any such losses will end up becoming embedded in the QDA process. TDNA can, by aligning linguistic networks with QDA, not only bring out the gains, but it can also substantially reduce the losses that are linked to contexts related to both the linguistic and social interaction scale. In other words, TDNA presents a new way to introduce an interconnected type of context.

At this stage we are not proposing that TDNA results can be seen to ‘live up to’ the ‘hard’ quantitative criteria. The problematisation of this aspect can only emerge meaningfully as the proposed methodology gets to be used. In such a scenario it is likely that, for example, the dynamics of a more traditional notion of validity will emerge. Not because it is inherently better or more desirable in itself than any qualitative counterpart, but because with analysing large data sets the construct could serve as a fruitful one to draw on. At the same time, it needs to be recognized that since language is constructive and functional, no single reading can immediately yield in-depth understandings that are ‘right’ and/or ‘valid’/‘true’ (Willig 2013, 370). That is, the measures can never be assumed to immediately measure any quality objectively, so multiple iterations are and comparisons with original data are needed. But, better interpretations and more trust in the measures are achieved, they will get to serve the purpose of ordering and categorizing discussion networks and thematic maps.

The proposed analytical interpretations may also become constrained by the way that a network gets to be constructed. We have argued that a sequential approach that is based on word adjacency is the most fruitful and meaningful, but this may not always be the case. For example, instead of removing words, they might instead be associated with particular ways of linking other words. This brings the central strength of TDNA to the fore: by using TDNA, linguistic interpretations can be reintroduced into the context of the whole group discussion for the purpose of understanding what themes in the discussion elicit the use of a group of words and phrases that are related to a particular way of reasoning. As a non-trivial example, consider the word *actually*. In terms of a QDA, *actually* may signify attempts to persuade and might fruitfully be seen as a type of link rather than a type of concept (node). Hence, in future developments of our proposed methodology, different types of links could be treated by creating layered networks and perform the analysis on these. In such networks, each layer would represent a particular kind of linking behaviour, while the nodes get held constant. Many of the measures and the computer algorithm used in our illustrative analysis have been generalized to these layered networks (often called multiplex networks). This implies that one layer of the network would be dedicated to links depicting discursive actions such as ‘persuasion’, while others might be dedicated to ‘causal reasoning’. This would open the data set for new types of interpretation.

**Strengths and limitations**

As we have argued repeatedly, the main strength of the methodology is that it analytically includes operationalizing the notion that group discussions in a way that leads to the creation of a structural representation of the dynamics of a discussion. When linked iteratively to a QDA in the way we have outlined, this opens up for new lines of inquiry and interpretations that are not available or extremely hard to come by without the proposed TDNA methodology.

At the same time, TDNA presents an analytically robust way of effectively dealing with large data sets while keeping in a functional focus for effective screening for particular meanings and interactions for in-depth analysis. Once the pre-processing rules have been made for a large enough sample of group discussions, one becomes ‘equipped’ to try out the different rules on a larger set. This will arguable allow for systematic analysis that would be too time consuming when attempted with existing mainstream methodology. If the proposed approach produces meaningful results, then also it should become possible to compare discussions with measures external to the group discussions, such as, participation in social networks (Bruun 2016), attitudes to schooling, or performance.
In this sense, the main limitation of the proposed methodology could lie in its apparent complexity: the ability to conduct both QDA and NA in their own rights and to work with both the mathematical and visual sides of network analysis in ways that facilitate the coupling of these to thematic discourse analysis to attain a more comprehensive analysis than is possible using QDA or NA on their own.

Concluding remarks

To sum up our argument for this methodology, we have presented a novel way of enhancing the analysis of emergent learning in classroom group discussion. We have illustrated how such analysis is not possible by either QDA or NA on their own. Yet, in an educational setting, insights into these aspects are extremely desirable if teachers are going to be empowered to create optimum learning scenarios for group discussion learning. In other words, we have illustrated how it is possible to methodologically add a layer of transparency to traditional QDA. Here, all choices can be noted in all stages of the process, and in principle, every iteration can be reproduced. This means that each step can be scrutinized and changes can be made according to new ideas and insights.

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