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Just plain peers across social networks: Peer-feedback networks nested in personal and academic networks in higher education

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ABSTRACT

Peer feedback (PF) is often referred to as a socially mediated learning process. Nevertheless, the surrounding social networks, within which PF interactions are nested, are often neglected. This study examines PF, personal, and academic networks in higher education to identify any peer centrality pattern. Additionally, the PF content is examined to identify any content-related pattern across PF networks. Participants were 47 master students in a German university. A subsample of 32 students, who voluntarily participated in two learning communities, so called Communities of Learning Practice (CoLP), was further examined in terms of PF networks and content of provided PF. Data were collected from social network questionnaires (cohort level) and video recordings of community events (CoLP level). Data analysis involved (a) contextual SNA of questionnaire data to identify participants' centrality in personal and academic networks, (b) SNA of video data to identify CoLP members' centrality in PF networks, and (c) content analysis of video data to identify the content of PF provision. Findings indicate a heterogeneous centrality pattern across networks and a homogeneous content-related pattern in the provided PF across CoLPs. This study aims to contribute to the reconceptualization of PF as a web of socially nested and multiplex learning interactions.

1. Introduction

From a social network perspective, learning constitutes a relational process that depends on and involves interactions (e.g., information exchanges, discussions, dialogic feedback, questioning) through an ongoing meaning negotiation process between individuals, who build a joint social learning experience (Haythornthwaite, 2008). The examination of social network interactions constitutes a prerequisite for comprehending how learners engage with each other towards jointly building a learning community (Haythornthwaite, 2008). By viewing learning as being socially constructed and mediated within learning communities, the embedded social relationships and social dynamics among individuals, who participate in any dialogically constructed and socially mediated learning practice, constitute important learning components.

Several researchers extensively examined social networks and learning communities from a social network theory/analysis perspective in educational and/or broader learning settings with predominant interest in computer-supported social networks and communities (e.g., Cho, Gay, Davidson, & Ingraffea, 2007; Dawson, 2008; Haythornthwaite, 2001, 2002). More specifically, researchers investigated the relationship between pre-existing social networks (e.g., interpersonal relationships) and student or group performance and found a positive relationship (e.g., Jehn & Shah, 1997; Shah & Jehn, 1993). Others focused on the role of pre-

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existing social networks in information sharing and learners' actions in computer-supported collaborative learning environments and found a positive relationship likewise (Cho et al., 2007; Cho, Stefanone, & Gay, 2002). Haythornthwaite and Wellman (1998) examined the role of strength of friendship ties and work ties in individuals' frequency of interactions and kinds of information exchange and found that individuals with strong ties, either friendship or work ties, interact more frequently and exchange more kinds of information than those with weak ties. Finally, Dawson (2008) examined the relationship between students' network positioning and their sense of community and found a positive relationship. Dawson (2008) further claims that the identification of students' positions in pre-existing personal networks may inform students' positioning in the co-construction of knowledge in social learning environments. These studies indicate that the examination of social networks in relation to social learning situations is a worthwhile endeavor.

A learning practice that is highly associated with the view of learning as being dialogically constructed and socially mediated is that of peer feedback (e.g., Carless, 2013; Nicol, 2010; Strijbos & Müller, 2014; Villamil & De Guerrero, 1996, 2006; Yang & Carless, 2013). Peer feedback, as a branch of feedback that involves peers as information sources on one's performance, has attracted considerable interest, mainly in the field of higher education, due to its perceived contribution to assessment practices and students' learning outcomes and skills (see Evans, 2013). Despite the widespread acknowledgement of the social dimension of peer feedback and its potential contribution to assessment and/or learning practices in higher education, the role of peers as social actors in social networks that surround and penetrate peer-feedback interactions in higher education and subsequently the role of these networks in peer-feedback interactions has been overlooked. This gap potentially lies in the predominant association of peer feedback with assessment practices that rarely extend to the socio-structural elements of peer-feedback interactions and interactants. Moving beyond any association of peer feedback with formally designed assessment practices, this study aims to address this gap by examining the relationship between peer feedback providers' centrality in peer-feedback, personal, and academic networks within the context of higher education.

The following subsections provide a brief overview of the (1) social network paradigm, (2) dominant perspectives on peer feedback in educational contexts, and (3) current peer feedback (re)conceptualizations that move beyond traditional assessment practices in higher education and shift the focus to peer feedback as an inherent social learning practice. The last subsection presents (4) how all these ideas are brought together in this study, and finally, the aim and research questions are formulated.

1.1. The social network paradigm: an analytical and theoretical framework

Social network analysis (SNA) originated in the 1930s—with earlier antecedents that can even be traced back to the 1920s (see Freeman, 1996)—and was further systematized in the 1950s–1960s to become a recognizable paradigm in the 1970s (see Carrington, 2014; Freeman, 2004). Yet, only since the 1990s, interest has mounted in SNA across disciplines (e.g., mathematics, sociology, physics). In recent years, SNA has progressed dramatically and is vigorously promoted by current theoretical, methodological and technological advancements, constituting SNA highly popular across disciplines (Borgatti & Halgin, 2011; Crossley, Prell, & Scott, 2009; Wölfer, Faber, & Hewstone, 2015) (for a detailed historical review on SNA see Freeman, 2004).

SNA moves beyond a mere methodology or analysis technique to represent a network theory. Although the theoretical principles of SNA are rooted in relations, matrix algebra, and graph theory (i.e., branches in mathematics), they extend to a network theory of its own (e.g., Burt, 1992; Granovetter, 1973), which emphasizes the role of relationships among actors in explaining actors' and network's behavior and moves beyond actors' individual attributes (Borgatti, Brass, & Halgin, 2014; Borgatti & Halgin, 2011).

In general, a social network consists of a set of actors/agents (i.e., nodes or vertices) and their relations (i.e., ties or edges) (Wasserman & Faust, 1994) that is typically visualized as a sociogram (see Moreno, 1934), graph, or matrix. A social network represents a relational structure, which expresses the linkages between actors/agents (Scott, 2013). Social networks may be asymmetric (i.e., A to B does not by definition equal B to A) represented with a directed graph (i.e., A → B, A ← B) or symmetric (i.e., A to B equals B to A) represented with an undirected graph (i.e., A–B) (Carrington, 2014). The nodes in a social network may be individuals, groups, organizations, societies, or other. The ties may fall within one level of analysis (e.g., individual-to-individual ties), in one-mode (or monopartite) networks, or may cross levels of analysis (e.g., individual-to-group ties), in two-mode (or bipartite) networks (Grunspan, Wiggins, & Goodreau, 2014). Ties are classified in several ways including communication ties (e.g., who talks to whom), formal ties (e.g., who reports to whom), affective ties (e.g., who likes whom), material or work flows (e.g., who gives resources to whom), proximity ties (e.g., who is spatially closer to whom), and cognitive ties (e.g., who knows who knows whom) (Katz, Lazer, Arrow, & Contractor, 2004). Borgatti and Halgin (2011) classified ties even more inclusively as states and/or events. Examples of state-ties include affective ties and cognitive ties that can be characterized in terms of strength, intensity and duration. Examples of event-ties include communication ties and material or work flows that can be characterized in terms of frequency of occurrence. Yet, networks are multiplex, implying that actors are connected to each other with various tie-constellations, which may vary in direction (e.g., unidirectional, reciprocal), content, frequency, medium, and sign (e.g., positive, negative) (Katz et al., 2004). For example, in an educational context, students might be classmates (i.e., role-based ties) and friends (i.e., affective ties) and neighbors (i.e., proximity ties). Ties have been also classified as strong or weak (see Granovetter, 1973, 1983). Strong ties may refer to family and friendship networks, whereas weak ties may refer to acquaintance networks. The issue of tie strength, originating in Granovetter's work (1973), has attracted considerable interest by a vast number of scholars investigating weighted social networks, i.e. networks that involve ties that apart from being present or absent represent some sort of weight (e.g., intensity, duration, exchanges) (Opsahl, Agneessens, & Skvoretz, 2010). By considering the presence or absence of ties as well as the weight of the ties in a social network, the complexity of the network can be represented more concretely (Opsahl et al., 2010).

1.2. Peer feedback: an assessment practice in educational contexts

In the field of education, feedback, in its various forms, has been substantially associated with assessment practices (e.g., test-feedback, peer assessment, portfolio assessment) and learning practices (e.g., collaborative learning, socio-constructivism, peer learning, self-regulated learning) (e.g., Boud, Cohen, & Sampson, 2001; Strijbos, Narciss, & Dünnebier, 2010; Van Gennip, Segers, & Tillema, 2010). Narciss (2008) describes feedback as "all post-response information that is provided to a learner to inform the learner on his or her actual state of learning or performance" (p. 127), which can be either external (e.g., from teachers or peers), or internal (from the learners themselves).

A considerable body of research has focused on external feedback by the teacher/expert (e.g., Hattie & Timperley, 2007; Hyland & Hyland, 2006). In a recent review of 195 papers published between 1985 and 2014, Winstone, Nash, Parker, and Rowntree (2017) identified 159 empirical papers out of which 81% focused on expert feedback, predominantly in the context of higher education. Expert feedback refers to information provided by an expert as response to students' performance in a task towards reducing the gap between students' current level of performance and desired level of performance (Hattie & Timperley, 2007). However, a shift from summative assessment (i.e., evaluating the final product of one's work) to formative assessment (i.e., evaluating intermediate products) (see Wingate, 2010), has called for and opened the way to additional assessment sources, such as peers.

Since the 1980s, educational researchers, mainly in the context of higher education and writing instruction in English as a second language/English as a foreign language, have investigated "peer-involving" instructional, assessment or learning practices (e.g., DiPardo & Freedman, 1988; Evans, 2013; Hansen & Liu, 2005). Frequently used terms are *peer assessment* (e.g., Topping, 1998), *peer feedback* (e.g., Gielen, Peeters, Dochy, Onghena, & Struyven, 2010; Strijbos et al., 2010), *peer revision* (e.g., Villamil & De Guerrero, 1996), *peer response* (e.g., Berg, 1999; Zhu & Mitchell, 2012), and *peer review* (e.g., Brill & Hodges, 2011; Cho & MacArthur, 2010; Hansen & Liu, 2005); and these are mainly associated with formative assessment (e.g., Nicol & Macfarlane-Dick, 2006; Topping, 1998) and collaborative learning (e.g., Van Gennip et al., 2010). Despite their different implications, all these terms refer to the involvement of peers as sources of information on other peers' performance(s). Notwithstanding the considerable theoretical claims that support the value of involving peers in assessment practices, the involvement of peers as sources of information in educational contexts has yielded both benefits and challenges for educators and students (e.g., Cho & MacArthur, 2010; Liu & Carless, 2006; Patchan & Schunn, 2015; Poverjuc, Brooks, & Wray, 2012), underlining that peers' involvement in assessment should not be treated as a straightforward assessment practice.

1.3. Peer feedback beyond traditional assessment: a call for reconceptualization

Research on feedback in higher education revealed a "bipolar" profile of feedback, on the one hand, being troublesome and ineffective for students and on the other hand, being generally perceived as beneficial to students' learning (Beaumont, O'Doherty, & Shannon, 2011; Nicol, Thomson, & Breslin, 2013; Yang & Carless, 2013). This profile of feedback is also supported in more general terms by London (2015) stating that

> Feedback is an anomaly. People have a general sense that feedback is good to give and receive. But many people avoid it like the plague. They are uncomfortable telling others they have done well, and they feel even more uncomfortable telling others they have performed poorly. (p. xii)

Despite the "global usage" of feedback on myriads sorts of performance, the notion of feedback in education is mostly associated with one sort of performance, that is performance to be assessed, either in a summative or a formative way. However, summative and formative assessment practices for immediate tasks in the context of higher education have been recently criticized for not contributing to students' lifelong learning. As Boud and Falchikov (2006) highlight, "the discourse of assessment draws strongly on the metaphors of acquisition and judgment" (p. 406), as opposed to the metaphor of learning as participation, for example, in communities of practice (see Lave & Wenger, 1991; Sfard, 1998; Wenger, 1998). Recently, several researchers have called for a rethinking or reconceptualization of feedback as "assessment for learning" or "feedback for learning" in the context of higher education (e.g., Askew & Lodge, 2000; Beaumont et al., 2011; Boud, 2000; Boud et al., 2010; Boud & Falchikov, 2006; Boud & Molloy, 2013a, b; Merry, Price, Carless, & Taras, 2013; Nicol, 2013; Sadler, 2010, 2013; Sambell, 2016).

Along these lines, peer feedback, mostly examined within the framework of assessment feedback in higher education and writing instruction (Nicol, 2013; Strijbos et al., 2010), has been critically approached when tightly related to assessment feedback. Especially, when referring to formats of peer feedback in which students' scoring of peers' work contributes to grades—utilizing peers as surrogate markers of student work (Boud, 2000; Falchikov, 2001; Nicol, 2013). In fact, in cases of peer grading, students end up working against each other—explicitly or implicitly—as such inhibiting cooperation and peer learning principles (Boud et al., 2001; Nicol, 2013; Topping, 2005). Hence, peers should be used as active constructors of feedback in a knowledge-building process whereby learners take responsibility for their and others' learning—not grading (Nicol, 2013). In a similar vein, recent views to peer assessment have been more inclusive to refer to "an educational arrangement where students judge a peer's performance quantitatively and/or qualitatively and which stimulates students to reflect, discuss and collaborate" (Strijbos & Sluijsmans, 2010, p. 265). This view implies that peer assessment is or has the potential to be much more than peer grading (see also Boud, 2000; Falchikov, 2005; Liu & Carless, 2006; Nicol, 2013).

Moving beyond assessment design, peer feedback closely resembles the "feedback reality" in professional settings or other non-educational settings that move beyond ideas of traditional assessment (e.g., measuring, grading, marking) (Nicol, 2013). In other words, peer feedback is or has the potential to be much more than peer grading, when treated as an inherent aspect of social learning

processes in social learning environments that eschew the element of assessment design. As Boud and Falchikov (2006) claim, assessment should be reconceptualized to align to the lifetime character of learning "post-graduation", which is socially situated and embedded in real-life contexts and tasks therein, calling for a sustainable approach to assessment. Boud and Falchikov (2006) argue that sustainable assessment does not constitute a new classification of assessment, it rather builds on summative and formative assessment to promote long-term learning goals. Boud and Falchikov (2006) portray a more "contextualized, participatory and relational assessment regime" (p. 408), which emphasizes the importance of context, involves authentic representations and productions, promotes transparency of knowledge, builds learner agency, and constructs active learners. More recently, Boud and Molloy (2013a) highlighted that

> In the world of work, they [the students] will typically not have structured processes of learning. Continuing learning in work will require individuals, together with others (peers, consumers, various resources) to take their own initiatives to seek and utilize feedback in settings in which the imperative is productive work, not learning. (p. 6)

Along similar lines, Askew and Lodge (2000) also highlight the value of feedback in the so-called "co-constructivist model", in light of which feedback is constantly constructed through dialogical loops (i.e., constant loops of dialogues and information exchange) and learning responsibilities are shared towards a meta-learning process.

Notwithstanding the urgent call for reconceptualizing peer feedback in educational contexts, and mainly in higher education, that moves beyond traditional assessment practices, actual peer-feedback practices beyond traditional assessment are still underexplored. According to Hattie and Timperley (2007), "feedback has no effect in a vacuum; to be powerful in its effect, there must be a learning context to which feedback is addressed" (p. 82). What is missing in this statement, when considering peer feedback, is that apart from a learning context, there is a surrounding social (learning) context as well that enables peer feedback to be employed, as a social learning strategy, or as a social sharing mechanism. In other words, the social context(s) within which peer feedback is nested is often overlooked. Sociocultural theories of learning, situate cognition, knowledge, and learning in social settings in which they are embedded and dialogically constructed through interactions and mutual relations among learners (see Lave & Wenger, 1991; Vygotsky, 1930–1934/1978). Therefore, from this learning perspective, it is crucial to consider the social setting(s) within which any peer-feedback practice(s) occurs and within which peer relationships and interactions are dynamically co-constructed.

1.4. Peer feedback and social networks in the present study

1.4.1. Peer feedback in the present study

This study, inspired by reconceptualizations of feedback in higher education and building on Boud and Falchikov's (2006) argument that "we must not make the mistake of attributing all benefits of education to those aspects under the direct control of teachers or the curriculum" (p. 404), considers feedback, and in particular peer feedback, an authentic learning practice inherent in the lived-in experience of learners. The term peer feedback, as used here, lends itself an expansive and inclusive connotation that moves beyond traditional ideas of assessment (e.g., peer assessment), the process approach to writing (e.g., peer response, peer editing, peer review), and/or any other practices that are mainly associated with formal educational contexts.

Peer feedback, in this study, is examined in social learning situations in which it does not serve any formal assessment purposes, although still framed in an "institutional" educational context (i.e., higher education institution). Peer feedback includes, but moves beyond, task-specific feedback to further include global feedback on learning practices, learning styles, or even personal attitudes to learning in general or collaborative learning in particular, deriving from and associated with the surrounding socio-educational contexts and aspects of interpersonal relationships and communication within them. Peer feedback is perceived as a sharing mechanism within learning communities in higher education utilized by members (i.e., adult learners) to share knowledge, learning experiences, advice, perceptions, and/or attitudes in relation to acting and interacting across socio-educational contexts. Peer feedback is treated as an interpersonal communication process that aims to contribute to students' learning in the broader sense, that is, learning that moves beyond curricular objectives and derives from and is enabled by participation in learning communities to address learners' own and others' learning and any other needs. By adopting a sociocultural perspective on peer feedback, which underscores that the individual as well as the individual's learning experiences are embedded in the surrounding social context(s) (Vygotsky, 1930–1934/1978), special attention is paid to the social context(s) within which peer-feedback interactions take place (i.e., across-contexts social networks).

1.4.2. Social networks in the present study

According to Nardi, Whittaker, and Schwarz (2002), social networks "exhibit aspects of both *emergence*, being called into existence to accomplish some particular work, and *history*, drawing on known relationships and shared experience" (p. 207). This perspective is in line with Granovetter's (1973, 1983) notions of weak and strong ties, reflecting aspects of emergence and history, respectively. Along similar lines, peers in peer-feedback interactions are not mere feedback providers for the shake of providing peer feedback (i.e., emergence), but also peers who are socially situated in surrounding social networks built on and/or built along interpersonal peer relationships and/or other relationships within which they socially construct their positioning defined in and by the surrounding social networks (i.e., history). Taking into account both aspects of emergence and history in social networks, (emergent) peer-feedback interactions are considered in relation to their (historical) personal networks (i.e., reflecting relationships at a personal level) and academic networks (i.e., reflecting relationships at an academic level) that surround and penetrate them.

The social network nodes in this study refer only to students. Consequently, the networks in this study are one-mode (or monopartite) networks as opposed to two-mode (or bipartite) networks (e.g., linking students to groups) (Grunspan et al., 2014). Ties

in the personal and academic networks are binary (0/1) representing whether a relationship exists or not. These networks are asymmetric (i.e., directed graphs), implying that if A perceived B as a personal/academic connection it does not mean that B also perceives A as a personal/academic connection. Although some social network researchers have referred to friendship networks as representations of symmetric networks (i.e., undirected graphs) (see Wald, 2014), in this study the friendship networks (i.e., personal networks) are not represented as undirected graphs, but as directed ones, due to participants' possible different perceptions of who their friends (i.e., personal connections) are. The same applies to the academic networks and academic connections. Ties in peer-feedback networks are asymmetric as well as valued, i.e. weighted, representing the frequencies of exchanges from A to B. The network boundaries in this study were pre-defined/limited to (a) cohort students, both community and non-community members, which constitutes a naturally occurring boundary, and (b) the subgroup of community members, which constitutes a research interest-defined boundary.

1.4.3. Aim and research questions

Within this integrative framework and by building on prior research that considered the role of contextual and social variables in social learning processes, this study examines peer feedback as an authentic practice that is socially constructed and situated within dynamic learning interactions, which are in turn situated within the broader insitutionalized and non-institutionalized social contexts within which complex social dynamics also emerge, implying a "multi-in-situ-activity". This study aims to articulate a more comprehensive understanding of the interplay of personal and academic networks emerging within a socio-educational context(s) and peer-feedback networks nested within those. In particular, we examine peers' centrality in peer-feedback provision networks in Communities of Learning Practice (CoLPs) in higher education in relation to peers' centrality in the surrounding personal and academic networks.

Peer feedback might involve simple network structures with at least two nodes (i.e., dyads—node A giving feedback to node B) or might end up being complex network structures with symmetric and asymmetric ties (i.e., group reciprocal and non-reciprocal peer-feedback exchanges). Therefore, examining peer-feedback interactions as well as the content of these interactions from a network perspective has the potential to reveal the otherwise hidden peer-feedback structures, both in terms of interactions and their carried "inter-contents" of the provided feedback messages. This study aims to further contribute to the discussion on new ways of thinking about peer feedback through a reconceptualization of the place of peer feedback in learning back to its original place, i.e. students' social learning interactions.

To address the aim of this study, social network theory/analysis and peer feedback are brought together. The following research questions are addressed.

RQ1: What is the relationship between peers' centrality in personal and academic networks?

RQ2: What is the relationship between peers' centrality in peer-feedback networks and peers' centrality in personal and academic networks?

RQ3: What are the types and focus of peer-feedback provision episodes in CoLPs?

2. Method

This study employed a mixed-methods research (MMR) approach to SNA (i.e., integration of qualitative-quantitative and structural approaches) with an underlying pragmatic stance (i.e., research question as a guiding tool for the selection of methods and tools, Johnson & Onwuegbuzie, 2004). The rationale for the implementation of an MMR approach to SNA lies in (a) understanding more comprehensibly the relationship between social networks and peer-feedback processes and interactions in CoLPs and (b) understanding more insightfully the interwoven social dimensions of peer feedback through a mixture of reframing perspectives (Greene, Kreider, & Mayer, 2011; Teddlie & Tashakkori, 2009). The integration of MMR to SNA is suggested by researchers (e.g., Bellotti, 2015; Bolibar, 2016; Crossley, 2010; Edwards, 2010) not only to foster the "visibility" of the actors in a network, but also the "visibility" of the surrounding context(s) in relation to the network (Bolibar, 2016).

Besides the thus far recognizable dominance of research on quantitative aspects of SNA on large networks, heavily influenced by developments in mathematics, recent efforts into the inclusion of qualitative and mixed-methods in SNA are revitalized to re-direct SNA—ironically—back to its original roots, and call for a deeper understanding of social structures (Carrington, 2014; Wald, 2014). This is not to say that quantitative aspects are less valuable, rather the opposite. As Hollstein (2014) underscores, qualitative data alone are not sufficient for making any valid statements about network structures, since structural data are prerequisites for describing social networks. According to Hollstein (2014), quantitative network data refer to "data describing relations, interactions, and structures of networks in formal terms using numbers" (p. 9), whereas qualitative network data refer to data on "aspects of networks (that) are described in text form" (p. 9). Nevertheless, as Wald (2014) also highlights, a purely qualitative or purely quantitative approach to SNA would not capitalize on the full explanatory potential of SNA by consistently excluding from examination central aspects of the social network phenomena.

Arguing further for the implementation of an MMR approach to SNA, Edwards (2010) underscores that SNA is well-suited to mixing methods due to its parallel interest in both the structure of a social network and the interactions that form these structures. The understanding of the structures and interactions is enabled by the exploration of the content of the network as well as the actors' perceptions of the network. In line with Edwards' (2010) perspective, Crossley (2010) also argues that emergent properties (e.g., sharing meanings) which can be identified with qualitative strategies to SNA, tend to be overlooked by the quantitative strategies to SNA—but cannot be ignored.

2.1. Research context

The phenomenon of peer feedback is explored within the framework of a Communities of Learning Practice (CoLPs) project. The CoLP project lasted three consecutive academic years exploring three CoLPs (CoLP1: 2011, CoLP2: 2012, CoLP3: 2013). The CoLPs operated in parallel with a two-year international master's program in the Learning Sciences at a university in Germany. The CoLPs differed in their overall lifespan ranging from one semester to three semesters (CoLP1: 3 semesters, CoLP2: 2 semesters, CoLP3: 1 semester). Prior to each CoLP formation, students were briefly introduced to the idea of learning communities and peer feedback processes to orient them towards the nature of the CoLP and were invited to voluntarily initiate a learning community with the support of a researcher/non-peer participatory facilitator, in short referred to as participatory facilitator. For consistency purposes in this study, only the first community cycle of CoLP1 and CoLP3 were examined (see Table 1). CoLP2 has been excluded due to its structural difference. More precisely, CoLP2 was facilitated and coordinated by senior peers along with the participatory facilitator. Senior peers had an active role as community facilitators and contact people for the community members, likely affecting the community dynamics and resultant influence, positive or negative, on peer feedback interactions.

Table 1
Overview of CoLPs.

CoLP	Entry year	SS parallel with CoLP	CEs	Location	Overall sommunity lifespan	Examined community cycle in this study
CoLP1	2011	2	6	Campus	3 SSs	1st
CoLP3	2013	1	7	Campus	1 SS	1st

Note. SS = study semester. CEs = community events. Community cycle = series of community events.

Each community cycle involved a number of face-to-face meetings with community members and the participatory facilitator lasting approximately 2.5 h each. Hereafter, these meetings are referred to as Community Events (CEs). All CEs took place in a classroom on the university campus to facilitate video-recording of the events and students' mobility (i.e., easy and convenient access in alignment with students' course schedule). To foster the informal and pleasant atmosphere of the community setting, snacks and refreshments were freely available to the community members at each CE. The classroom layout was adapted in various formats of a round-table layout to foster community members' mutual visibility, possibility for interaction, and overall comfort.

Prior to the formation of each CoLP, a needs analysis survey was conducted for each cohort to gather information about possible students' needs, perceptions of peer feedback, and scheduling preferences to inform structural and practical decisions about the CEs to be negotiated with the participatory facilitator. The students who voluntarily participated in each CoLP were free to withdraw their participation at any time over the course of each CoLP. No ECTS credits were awarded to students for their participation in the CoLP.

Students who expressed interest in participating in the CoLP indicated their preferred thematic foci of the CEs after negotiation with the participatory facilitator. Both CoLPs shared similar thematic foci in their CEs, which were relevant to the members' curricular studies and their surrounding socio-educational contexts (see Table 2). In addition to the foci selected by the community members, two CE-foci were proposed and added by the participatory facilitator in negotiation with the community members (i.e., introductory and closing event). More specifically, (a) the first event for each CoLP functioned as an introductory session in which members were presented with the underlying community principles of the community events and the sharing mechanism of peer feedback, and (b) the last event for each CoLP functioned as a closing session in which members were encouraged to provide specific or overall feedback to each other and to the community as a whole.

Table 2
Thematic overview of community events per CoLP.

CoLP	CEs	Thematic focus
CoLP1	CE1.1	Introductory session: peer feedback training
	CE1.2	The power of language
	CE1.3	Design of power point presentations
	CE1.4	Poster design and presentation: part 1
	CE1.5	Poster design and presentation: part 2
	CE1.6	Closing feedback session
CoLP3	CE3.1	Introductory session: peer feedback training
	CE3.2	The power of language: words, voice and body in academic presentations
	CE3.3	Reviewing literature: reading theoretical and empirical papers
	CE3.4	Aspects of an article to consider in your presentations: what and how?
	CE3.5	Preparing your cover letters
	CE3.6	Actual performance only
	CE3.7	Closing feedback session

Note. CoLP = community of learning practice. CE1 = community event of CoLP1. CE3 = community event of CoLP3.

2.2. Participants

Forty-seven master students of a university in Germany (female 41, male 6; international 26, German 21; age range 21–31, M_{age} = 25.06, *SD* = 2.54) voluntarily participated in this study. Participants who joint the CoLPs in more than one community event were considered community members and subsequently constituted the purposive sample of this study. Any students with missing data that hindered the identification of their SNA centrality in any of the examined networks were excluded from the sample. Informed consent was obtained from all participants on the cohort and CoLP level. A detailed overview of the participants in both student cohorts and CoLPs is provided in Table 3.

A closer look at each CoLP-member's participation rate in the CEs is also warranted, since this information adds on to their participation profile. Table 4 provides an overview of participants' CE participation rate for both CoLPs. As shown in Table 4,

Table 3
Overview of participants on the Cohort and CoLP level.

Cohort/CoLP	*N*	M_{age}	Age_{range}	*SD*	Cohort students	Gender	Nationality	Entry year	SS
Cohort 1	23	25.09	21–31	2.84	26	F:19 M:4	German (12) International (11)	2011	2
CoLP1	13	25.15	22–31	2.85	26	F:12 M:1	German (6) International (7)		
Cohort 3	24	25.00	22–30	2.27	29	F:22 M:2	German (9) International (15)	2013	1
CoLP3	19	25.11	22–30	2.49	29	F:18 M:1	German (6) International (13)		

Note. Cohort students refer to the total number of students enrolled in the study program per cohort and constituted the convenience sample. SS refers to study semester parallel to the CoLP. Three participants (non-CoLP members) of Cohort 1 (3/26) and five participants (3 CoLP members and 2 non-CoLP members) of Cohort 3 (5/29) were excluded from the sample due to relevant missing data.

Table 4
Overview of participation in CEs per participant.

CoLP	Participants	Participation in CEs							Total (P)
		CE1	CE2	*CE3	CE4	CE5	*CE6	CE7	
CoLP1	C1.1	0	0	1	1	0	1	NA	3
	C1.2	1	1	0	0	1	0	NA	3
	C1.3	0	0	0	1	1	0	NA	2
	C1.4	1	1	1	1	1	0	NA	5
	C1.5	1	1	1	1	1	1	NA	6
	C1.6	1	1	1	1	1	1	NA	6
	C1.7	0	1	0	0	1	0	NA	2
	C1.8	1	0	1	0	1	1	NA	4
	C1.9	0	1	1	1	1	1	NA	5
	C1.10	1	0	1	1	1	1	NA	5
	C1.11	1	1	0	1	0	0	NA	3
	C1.12	1	1	1	0	1	1	NA	5
	C1.13	1	0	0	1	0	1	NA	3
CoLP3	C3.1	1	0	1	1	0	0	1	4
	C3.2	1	1	1	1	0	0	1	5
	C3.3	1	1	1	0	0	0	0	3
	C3.4	1	1	1	0	0	0	1	4
	C3.5	1	1	1	0	0	0	1	4
	C3.6	1	1	1	1	0	1	1	6
	C3.7	1	1	0	0	0	0	0	2
	C3.8	1	1	1	0	1	0	0	4
	C3.9	1	1	1	0	1	0	1	5
	C3.10	1	1	1	1	1	0	0	5
	C3.11	1	1	1	1	0	0	0	4
	C3.12	1	0	1	1	0	0	1	4
	C3.13	0	0	1	0	0	0	1	2
	C3.14	1	1	1	1	1	1	0	6
	C3.15	1	0	0	0	0	0	1	2
	C3.16	1	1	1	0	0	0	1	4
	C3.17	1	1	1	1	0	0	1	5
	C3.18	1	1	0	1	1	0	0	4
	C3.19	1	1	0	0	0	0	0	2

Note. NA = non-applicable (i.e., CoLP1 had only 6 CEs). *CE3 and *CE6 in CoLP3 were not included in the video data analysis.

participation rates vary in both CoLPs, with a minimum participation rate of two CEs and a maximum of six CEs. The average participation rate across participants was four CEs for both CoLPs. Participant C3.19 dropped out, but was still included in the sample since the participation rate was more than one CE and the SNA centrality in all social networks could be identified.

2.3. Instruments

2.3.1. Self-reported questionnaires

Self-reported questionnaires were used to collect data on complete networks, involving a roster of actors with whom the respondents were asked to recognize relationships—as opposed to ego network data collection instruments (e.g., name generators that involve recalling of relationships) (Carrington, Scott, & Wasserman, 2005; Crossley et al., 2015; Wasserman & Faust, 1994). Responses were in the format of binary judgments (0/1), termed sociometric choices, that revealed the presence or absence of relationships with actors on the roster (Carrington et al., 2005). All network relations were conceptually asymmetric without excluding empirical reciprocity or symmetry among some nodes (see Carrington, 2014).

The self-reported questionnaires were distributed once at the end of the targeted semester to reveal students' (a) personal networks and (b) academic networks. Personal networks were defined by the relationships students have with any of their classmates at a personal level and with whom they meet regularly within and outside the course context and university environment (e.g., visit social events together such as parties, go for lunch/dinner or coffee, go together for a walk at the park). Academic networks were defined by the relationships students have with any of their classmates at an academic level and with whom they meet and interact regularly only within the course context and university environment (e.g., study together at the library, work together on presentations, collaborative writing, share academic discussions during seminars/lectures or breaks). The aforementioned descriptions were provided to the participants prior to filling out the questionnaires to foster homogeneity in terms of what the personal and academic networks represent. Fig. 1 shows an extract of the template used to collect data on personal and academic networks. Students filled out separate social network questionnaires for the personal and academic network.

Self-reported questionnaire network data are informative in revealing social structures and patterns, but they are not sufficient for understanding how the self-reported ties relate to any other processes. To address this, data from video recordings were also collected and included in this study.

Social network at **[personal // academic]** level* of … [First Name, Last Name]	I have been **[personally // academically]** connected* with this person during the (semester).	
	Yes	**No**
Student 1	□	□
Student 2	□	□
Student X	□	□

Fig. 1. Extract of template used to collect data on personal and academic networks.

2.3.2. Video recordings

Three video cameras capturing three different angles (see Fig. 2)—fixed on the wall, but with the possibility to control (e.g., move, zoom in/out) them from the video recording room—were used to record audiovisual conduct of members participating in peer-feedback interactions in the CoLPs (see also Hmelo-Silver, Kati, Nagarajan, & Chernobilsky, 2006). The obtained data were not experimental, but "natural" since participants' behavior was not scripted. According to Knoblauch, Schnettler, and Raab (2012), natural data refer to "data collected when the people studied act, behave and go about their business as they would if there were no social scientists observing or taping them" (p. 11). It should be highlighted though that some of the peer-feedback activities were initiated by the participatory facilitator to foster members' peer-feedback interactions and members were randomly selected to contribute either as peer-feedback seekers or peer-feedback providers. Nevertheless, the participatory facilitator's initiation of activities and random selection for contribution was not based on any experimental conditions or purposefully designed interventions.

The video data corpus consisted of approximately 13 h. of video recordings for CoLP1 (CoLP1: 6/6 CEs); and 15 h. of video recordings for CoLP3 (CoLP3: 5/7 CEs). The minimum CE duration was approximately 2 h. (CE1.1) and the maximum CE duration was 3.5 h. (CE3.7). Since this study focuses on peer-feedback interactions and practices, the complete video data set was initially segmented into peer-feedback episodes, namely any meaningful episodes that involved verbal or non-verbal (i.e., peer-feedback cards) peer-feedback exchanges. The segmented peer-feedback provision episodes were further analyzed by two individual coders both structurally, with social network analysis, and content-wise with content analysis. These data analysis approaches were used complementarily.

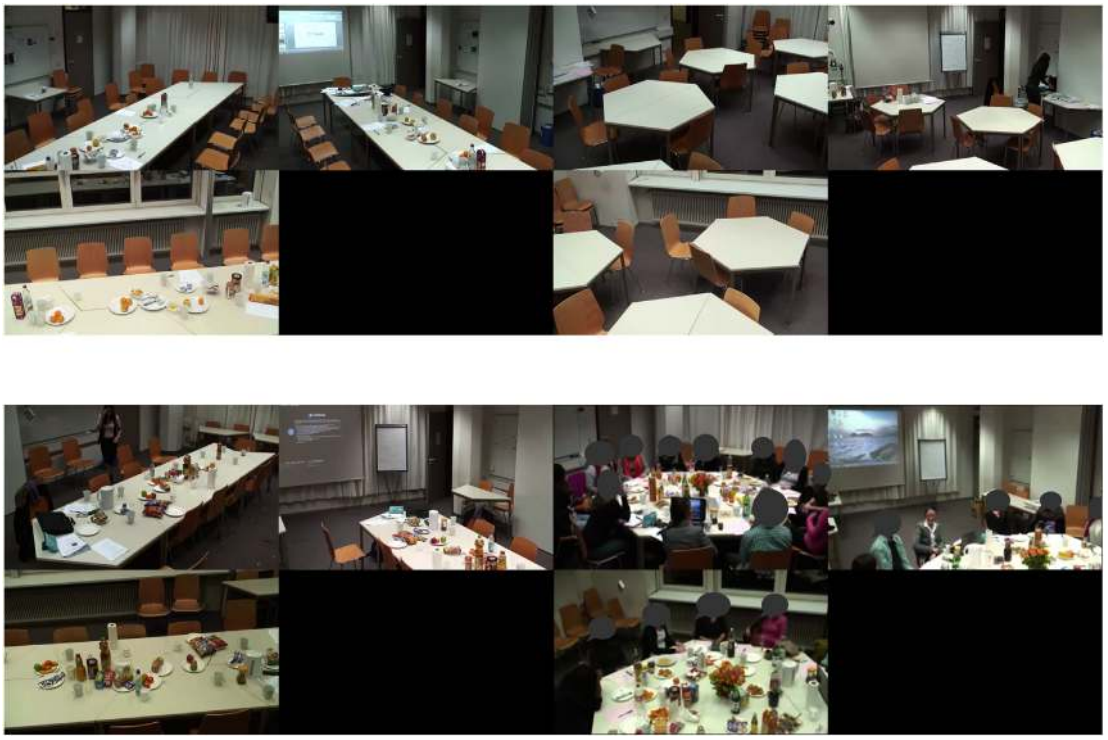


Fig. 2. Video camera angles in the community events.
Note. Three perspectives of video cameras with a synchronous emphasis on the presenter, the whole CoLP and a sub-group of interest. Four CEs with different classroom layouts are included.

2.4. Data analysis

In close alignment with De Laat, Lally, Lipponen, and Simons's (2007) multi-method approach to SNA, this study implemented (a) SNA to reveal who is providing peer feedback to whom while taking into consideration relevant weights, (b) content analysis (CA) to reveal the type and focus of the provided peer feedback, and (c) contextual SNA (CxSNA) to identify the personal and academic networks that surround and penetrate the peer-feedback interactions (i.e., peer-feedback provision) (see Fig. 3).

The CxSNA adds the provision of contextual information in terms of the surrounding networks and whether and how they are transferred and relate to processes within the specific peer-feedback situation under examination. In this study, CxSNA is still considered contextual analysis, but from an SNA perspective. More details on SNA and CA, as implemented in this study, are provided in the next subsections.

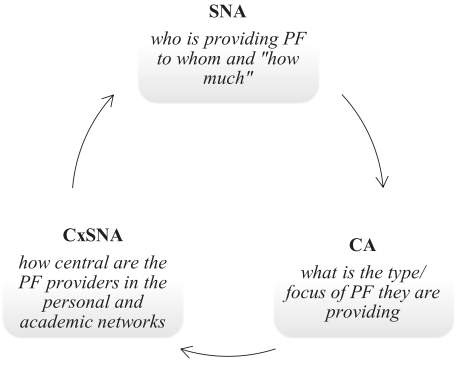


Fig. 3. An MMR framework for studying peer-feedback provision in CoLPs (adapted from De Laat et al., 2007).
Note. PF = peer feedback. The original framework is referred to as multi-method framework and it involves context analysis (CxA) as opposed to Contextual Social Network Analysis (CxSNA).

2.4.1. Social network analysis

Two frequently used descriptive SNA measures were conducted in this study, that is (a) centrality measures on the actor/agent level and (b) the density measure on the whole network level. After considering the representation of the nodes and ties in the networks included in this study, as suggested by Borgatti (2005) for selecting which centrality measures are applicable, Freeman's (1979) degree centrality and Bonacich's (1972) eigenvector centrality were used. Centrality is one of the most frequently used concepts in social network analysis and degree centrality and eigenvector centrality are among the best known centrality measures (Borgatti, 2005; Opsahl et al., 2010).

Degree centrality refers to the number of ties falling upon and departing from a node (i.e., direct influence) and it is considered a suitable measure for situated knowledge construction (Borgatti, 2005). The degree centrality measure was used to identify central and peripheral participants within (a) the peer-feedback network on the CoLP level (e.g., A provides feedback to B) as observed in the video data, (b) the personal network on the cohort level (e.g., A is personally connected to B) as self-reported in the questionnaires, and (c) the academic network on the cohort level (e.g., A is academically connected to B) as self-reported in the questionnaires. According to Borgatti (2005), the eigenvector centrality is defined as the principal eigenvector of the adjacency matrix defining the network. The eigenvector centrality of an eigenvector v is given by: $\lambda \boldsymbol{v} = \mathbf{A}\boldsymbol{v}$, where $\mathbf{A}$ is the adjacency matrix of the graph, $\boldsymbol{\lambda}$ is the eigenvalue, and $\boldsymbol{v}$ is the eigenvector. A node with high eigenvector centrality is adjacent to nodes that have high eigenvector centrality themselves.

Three types of degree centrality were used. In the analyses of the personal and academic social networks on the cohort level the overall degree centrality was used (i.e., the sum of in-degree and out-degree centrality for each member), which indicated the sum of both the number of nodes falling upon one node and the number of nodes departing from one node. The ties were directed and represented in an asymmetrical graph, implying no immediate reciprocity. In the analyses of the peer-feedback networks extracted from the video data, two types of degree centrality were considered, namely (a) overall weighted degree centrality (i.e., the sum of weighted in-degree centrality and weighted out-degree centrality) and (b) weighted out-degree centrality. The overall weight of each tie represents the number of peer-feedback provision episodes falling upon and departing from each node, whereas the weighted out-degree refers only to the number of peer-feedback episodes departing from one node. For example, A provided peer feedback to B ten times (10 is the weighted out-degree for A) and B provided peer feedback to A five times (5 is the weighted in-degree for A), resulting into an overall weight of 15 for A.

The whole network-level measure was that of density. Density is defined as the ratio of the total number of edges present in a graph to the total possible edges in the graph (Carrington, 2014; Khokhar, 2015). Density constitutes a measure that indicates the connectedness within a network (De Laat et al., 2007). The density was calculated on the basis of the potential complete network per situation, i.e. all potential cohort members for the personal and academic network, and/or all potential CoLP members for the personal-CoLP, academic-CoLP, and peer-feedback network.

The Gephi (Version 0.9.1) software (Bastian, Heymann, & Jacomy, 2009) was used for the social network analysis. Gephi is an open source interactive graph visualization, exploration and manipulation software used to identify, represent, analyze and visualize nodes (i.e., students) and edges (i.e., relationships, peer-feedback exchanges) from relational data (i.e., questionnaires, video data) and communicative data (i.e., video data). The generated visual representations are considered vital for the understanding of network data and for conveying the results of the analysis.

2.4.2. Content analysis of video data

Content analysis (CA) was conducted on the video data with a pre-defined, but still contextually situated, peer-feedback coding scheme. CA refers to a technique that allows replicable and valid inferences to be extracted from data sources that are meaningful to their framing contexts (Krippendorff, 2013). Although CA is considered to be a powerful technique to uncover learning processes, it is still labor intensive and time-demanding (De Laat et al., 2007). Nevertheless, the complete corpus of the collected video data was analyzed. Only 2 out of 7 CEs of CoLP3 were excluded due to their inappropriateness for inclusion (i.e., information session with no peer-feedback episodes and one CE with only two participants).

To avoid the pitfall of treating the results of CA as data themselves – a practice that can distantiate the reader from the real data and the phenomena being studied – fundamental standards for reporting the employed methods have been taken into consideration (Hammer & Berland, 2014; Schoenfeld, 1992). With a predominantly ethnographic orientation, Angelillo, Rogoff, and Chavajay (2006) explicitly point to the challenge—but still a necessity—of developing coding schemes to examine "between-person engagement *explicitly*" (p. 189) in social learning contexts. To capture the between-person engagement in CoLPs and in line with Angelillo et al.'s (2006) perspective, the content analysis in this study aimed not to simply capture "what" (i.e., peer-feedback focus) individuals contributed in the CoLP, but also "to whom" individuals contributed and "how" (i.e., what type of peer feedback) individuals contributed to each other. In other words, CA aimed to unravel emerging social interaction patterns (i.e., peer-feedback patterns), supporting the value of integrating MMR to SNA to uncover emerging properties of a network (Crossley, 2010). Therefore, CA and detection of peer-feedback actors (i.e., peer-feedback providers and peer-feedback recipients) was employed in parallel.

The coding scheme consisted of twelve codes (see Table 5). Eight codes addressed the peer-feedback provision aspect of peer-feedback episodes (Level 1) and four codes addressed the peer-feedback focus reflected in the peer-feedback provision episodes (Level 2). The coding scheme was developed in such a way to enable the identification both of the type of the peer feedback provided (i.e., the "how" of the peer feedback) and the focus of the peer feedback provided (i.e., the "what" of the peer feedback).

The MAXQDA Plus 12 software (Release 12.3.1) was used for the analysis of the video data. The complete set of video data was analyzed for the identification of peer-feedback provision episodes and the involved actors. Two independent coders segmented the video data of CoLP3 with 70% agreement and one coder independently proceeded with the segmentation of peer-feedback provision

Table 5
Peer-feedback coding scheme used in content analysis of video data.

Code name	Label	Description	Example
Level 1: peer-feedback provision			
Verification-positive	VP	All statements, comments and reactions that contain a positive evaluation of the performance. Focus on the actions that were done correctly.	"Your presentation was very well structured,"
Verification-negative	VN	All statements, comments and reactions that contain a negative evaluation of the performance. Focus on actions that were done incorrectly (i.e. problems, mistakes, gaps, etc.).	"but you speak too fast!"
Question	Q	All questions that prompt reflection. They do not contain an alternative or implicit suggestion for improvement or concrete action by the recipient.	"How would you improve your presentation?"
Suggestion	SU	All statements and comments that follow a positive or negative verification. The offered suggestion provides an alternative or alternatives for performed activities or choices made and prompts concrete action by the recipient.	"I would suggest to change the font size…"
Argumentation	AR	All statements, comments that follow and/or proceed a positive or negative verification, question, or suggestion. Argumentation provides a ground/reason/argument/elaboration/exemplification on a previous or following statement, for example on a negative evaluation or the alternative suggested by the provider. Argumentation can be offered in the form of additional information, examples, use of criteria.	"…because it's too small."
Affect: effort acknowledgement	EA	All statements and comments acknowledging the effort of the recipient.	"It's obvious that you have worked hard on this!"
Affect: interest	IN	All statements, comments, questions and reactions that express interest and curiosity towards the performance.	"After your presentation I would like to know more about the topic."
Affect: support/ encouragement	SE	All statements, comments and actions that are intended to encourage or support the recipient.	"I'm sure that you will be great tomorrow!"
Level 2: feedback focus			
Skill/task performance related	SK	All statements and comments that act as feedback to participants' skills/task performance/overall performance within or outside the setting of the community events.	"During your presentation I noticed that you were moving your hands quite nervously."
Study program related	ST	All statements and comments that act as feedback to participants referring to study program situations (e.g., class situations, group work situations) beyond the community events.	"I like our collaboration in our group assignments."
Personal	PE	All statements and comments that act as feedback to participants personality/personal attitudes (e.g., personality, attitudes to specific situations).	"You are very reliable."
Social	SO	All statements and comments that act as feedback to participants social engagement/social contribution/organization of and/or participation in social activities.	"You organize very well social activities that bring us together."

episodes in CoLP1. A peer-feedback provision episode refers to any statement, comment or expressed reaction (i.e., card with feedback comments shown to the recipient without being verbalized) on one's skills/task performance, study program situations, personality and/or general attitude to specific situations, and/or social engagement/social contribution without considering the recipient's response(s). Consequently, responses by peer-feedback recipients were not considered for further analysis.

By considering the Level 1 categories of the coding scheme, two independent coders proceeded with the coding of 84 out of 1024. The selected 84 episodes were of community event CE1.6 (CoLP1). This event was selected due to the large number of identified segments and its potential variability in codes. Cohen's kappa was used to calculate inter-rater reliability. Cohen's kappa was 0.57 in trial 1, which was considered insufficient. After trial 1, the coders modified the code Justification to Argumentation after negotiation, as the Justification code was too restrictive (i.e., reason for a statement that aimed to convince the recipient). After implementing this change, the two independent coders proceeded with trial 2 on 93 out of 1024 additional segments of the same CE (i.e., CE1.6 in CoLP1) and achieved a Cohen's kappa of 0.86, which was considered satisfactory. One coder proceeded with the coding of the remaining segments. No non-codable segments were identified since the criterion for the segmentation of the episodes was to be a peer-feedback provision episode that could fit in one of the codes.

By considering the Level 2 categories of the coding scheme, two independent coders proceeded with the coding of 101 out of 1024 segments. The selected 101 episodes to be coded were also episodes of the community event CE1.6. Cohen's kappa was 0.70 in trial 1 which was considered satisfactory. One coder proceeded with the coding of the remaining segments for both CoLPs.

3. Results and discussion

3.1. RQ1: What is the relationship between peers' centrality in personal and academic networks?

The personal and academic networks on the cohort level were initially investigated as whole-network structures. The density of the directed personal and academic networks varied within and across cohorts. In Cohort 1, the academic network showed higher density than the personal network, whereas the opposite was observed in Cohort 3 (see Table 6).

Following the density measure (i.e., whole-network measure), (a) degree centrality (i.e., actor measure; the sum of both the in-degree and out-degree centrality of actors) was computed to identify the central and peripheral nodes, and (b) eigenvector centrality was computed to identify important nodes in the personal and academic networks on the cohort level. An overview of the centrality measures for all nodes in the personal and academic network for Cohort 1 is provided in Table 7 and visualized in Fig. 4 and for Cohort 3 in Table 8 and visualized in Fig. 5. Nodes in Tables 7 and 8 are ordered from highest to lowest (overall) degree centrality in the personal network. Cohort students' (i.e., CoLP and non-CoLP members) centrality in Figs. 4 and 5 is displayed with a size ranking of the nodes (i.e., larger nodes represent higher centrality ranking). The nodes are also displayed with a color partition that implies CoLP membership or not. The color green in both figures indicates the nodes that were not CoLP members. The directed ties in the network visualizations are not weighted, representing only the personal and academic connections from one node to another. Nevertheless, students' centrality is defined by different criteria in each visualization (i.e., overall degree centrality and eigenvector centrality) for each cohort.

Table 7 shows the centrality measures (i.e., in-degree, out-degree, overall degree and eigenvector centrality) for Cohort 1 students in personal and academic networks. It can be observed that there is a variation in degree centralities within and across networks. The personal and academic centrality pattern as represented in the personal and academic network of Cohort 1 is illustrated in Fig. 4. As evident in Fig. 4, all Cohort 1 students appear in the network, implying that all Cohort students were connected with other students to

Table 6
Graph density: personal and academic networks on the cohort level.

	Cohort 1	Cohort 3
CoLP members %	56.52%	79.17%
Density personal	0.340	0.527
Density academic	0.423	0.467

Table 7
Cohort 1: centrality measures in personal and academic networks.

Label	In-degree PE	Out-degree PE	Degree PE	EV-PE centrality	In-degree AC	Out-degree AC	Degree AC	EV-AC centrality
C1.4	10	16	26	0.956	7	18	25	0.525
NC1.23	8	18	26	0.677	13	16	29	0.977
C1.12	11	13	24	0.974	13	8	21	0.946
C1.3	10	10	20	0.937	8	3	11	0.616
C1.8	8	12	20	0.637	4	12	16	0.242
C1.13	9	11	20	0.909	10	6	16	0.700
C1.9	10	9	19	0.993	11	6	17	0.835
C1.2	7	11	18	0.551	9	13	22	0.649
C1.7	10	7	17	0.919	10	9	19	0.724
NC1.19	5	12	17	0.464	9	22	31	0.646
C1.5	12	4	16	1	14	5	19	1
C1.11	10	6	16	0.994	11	15	26	0.853
C1.10	9	5	14	0.774	11	8	19	0.857
NC1.21	8	6	14	0.599	10	5	15	0.688
C1.1	8	3	11	0.728	9	2	11	0.621
NC1.14	6	5	11	0.413	14	10	24	0.980
NC1.20	5	6	11	0.441	9	13	22	0.613
NC1.17	6	3	9	0.484	7	9	16	0.628
NC1.22	5	4	9	0.530	6	16	22	0.490
C1.6	7	0	7	0.625	9	4	13	0.662
NC1.18	3	4	7	0.288	6	4	10	0.386
NC1.15	5	1	6	0.281	9	5	14	0.589
NC1.16	0	6	6	0.000	5	5	10	0.283

Note. C1 = CoLP1 members, NC1 = non-CoLP1 members. PE = personal network. AC = academic network. EV-PE = eigenvector centrality in the personal network. EV-AC = eigenvector centrality in the academic network.

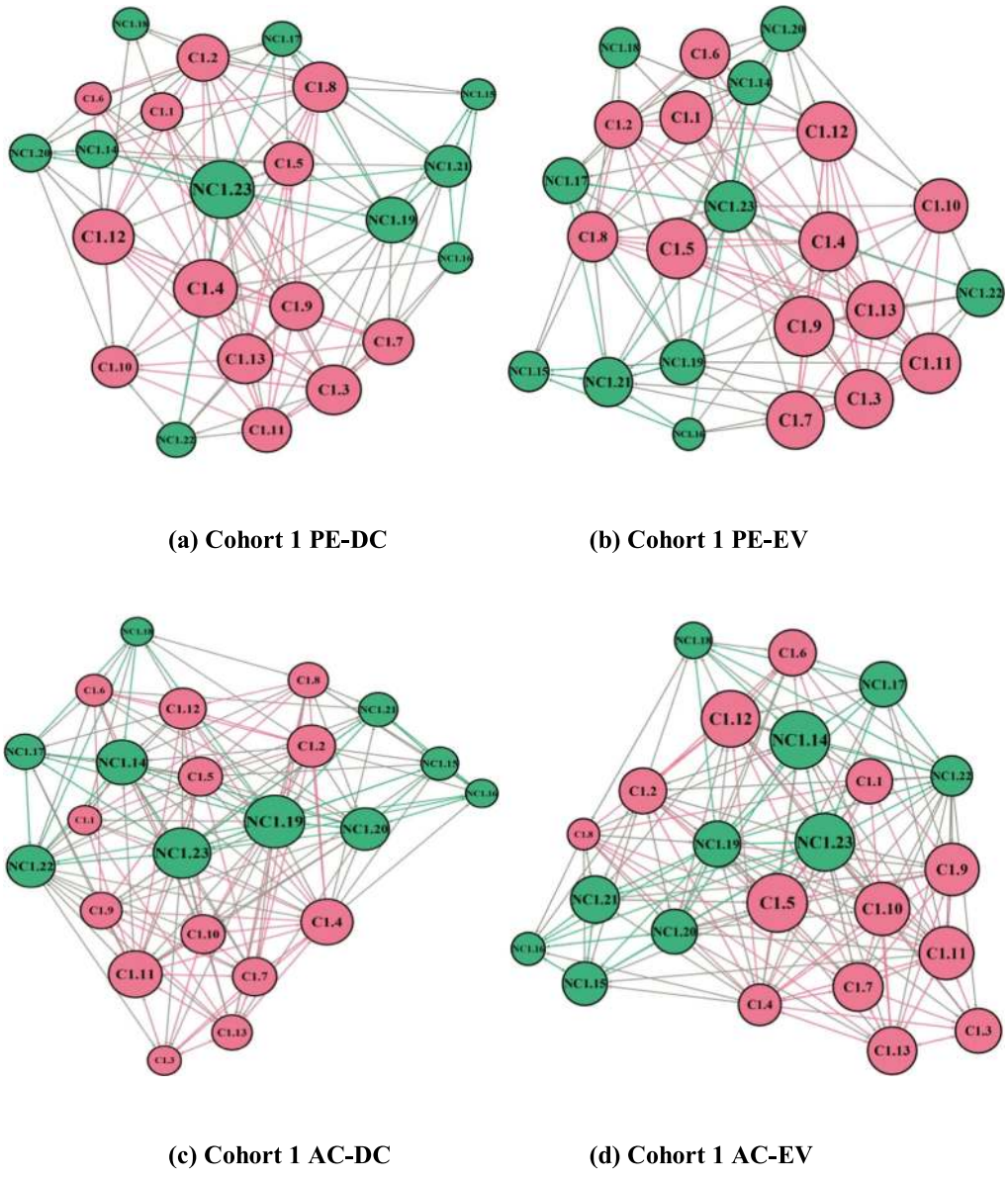


Fig. 4. Cohort 1: degree centrality (DC) and eigenvector centrality (EV) in personal (PE) and academic (AC) networks.
Note. NC1 stands for non-CoLP1 members. C1 stands for CoLP1-members. PE-DC = degree centrality in the personal network. PE-EV = eigenvector centrality in the personal network. AC-DC = degree centrality in the academic network. AC-EV = eigenvector centrality in the academic network. The preview and layout settings on Gephi were identical for all network visualizations to avoid any visual misrepresentation of nodes' centrality.

some extent in the personal and academic networks. The same observation applies to Table 8 and Fig. 5 for Cohort 3. Fig. 4 reveals that CoLP1 members seem to have higher degree and eigenvector centrality than non-CoLP1 members in the personal network. Whereas no such pattern is indicated in the academic network of Cohort 1. Spearman correlation was also computed to confirm or reject this visual indication and a moderate positive correlation between degree centrality in the personal network and CoLP membership was found, $r(23) = 0.52$, $p = 0.011$, as well as a strong positive correlation between eigenvector centrality and CoLP membership $r(23) = 0.81$, $p = 0.000$. In Fig. 5 no pattern of centrality in terms of CoLP membership or not is evident since the majority of the Cohort students were also members of CoLP3. Spearman correlation was also computed to assess any relationship

Table 8
Cohort 3: centrality measures in personal and academic networks.

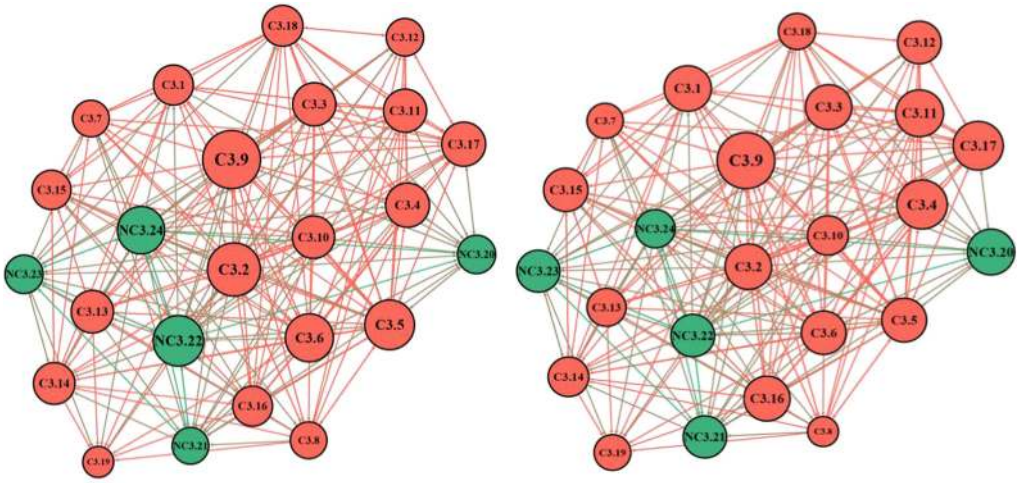
Label	In-degree PE	Out-degree PE	Degree PE	EV-PE centrality	In-degree AC	Out-degree AC	Degree AC	EV-AC centrality
C3.9	20	23	43	1	16	18	34	1
C3.2	14	23	37	0.706	13	14	27	0.829
NC3.22	12	22	34	0.624	12	12	24	0.779
C3.5	13	20	33	0.662	7	1	8	0.399
C3.6	12	19	31	0.651	14	4	18	0.845
NC3.24	10	20	30	0.515	8	11	19	0.546
C3.4	16	10	26	0.810	13	15	28	0.809
C3.17	15	11	26	0.795	11	8	19	0.691
C3.3	13	12	25	0.695	10	13	23	0.671
C3.11	14	11	25	0.744	11	14	25	0.693
C3.10	10	14	24	0.548	13	9	22	0.845
C3.13	10	14	24	0.502	12	18	30	0.756
C3.14	11	12	23	0.550	10	14	24	0.589
C3.18	8	14	22	0.453	8	11	19	0.535
C3.1	14	7	21	0.715	11	4	15	0.710
C3.16	14	7	21	0.690	13	7	20	0.810
C3.15	13	7	20	0.648	11	11	22	0.729
NC3.20	13	6	19	0.716	8	13	21	0.542
NC3.23	13	6	19	0.610	12	9	21	0.777
C3.12	12	6	18	0.630	12	13	25	0.736
C3.7	8	9	17	0.426	8	12	20	0.548
C3.8	5	12	17	0.284	8	19	27	0.515
NC3.21	12	5	17	0.615	10	1	11	0.635
C3.19	9	1	10	0.439	7	7	14	0.445

Note. C3 = CoLP3 members, NC3 = non-CoLP3 members. PE = personal network. AC = academic network. EV-PE = eigenvector centrality in the personal network. EV-AC = eigenvector centrality in the academic network.

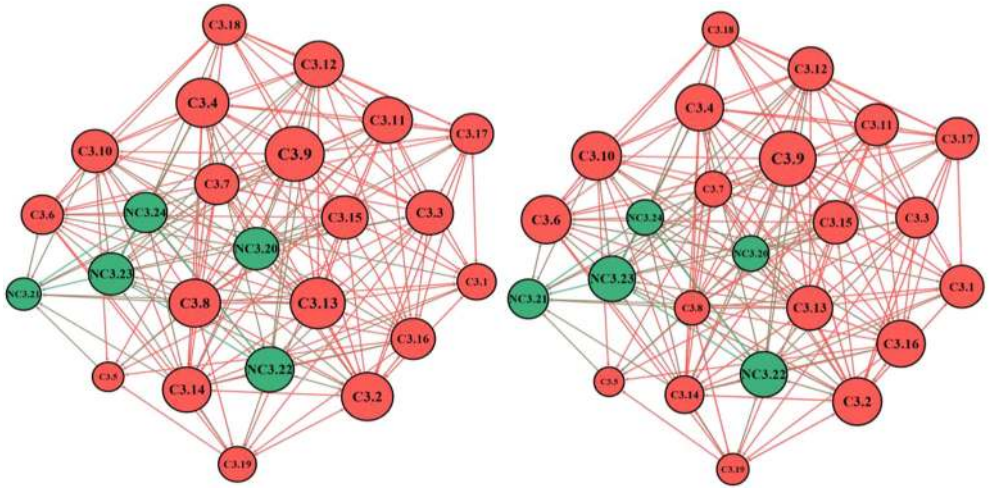
between degree and eigenvector centrality and CoLP membership and no correlation was found. Nevertheless, what stands out in Fig. 5 is that cohort student C3.9 retains a highly central position across networks, whereas other cohort students' centralities vary across the network visualizations.

Spearman correlation was computed to assess the relationship between participants' overall degree centrality and eigenvector centrality in personal networks and academic networks. A positive correlation was found between overall degree centrality in the personal and academic network for Cohort 1, $r(23) = 0.46$, $p = 0.026$, whereas no correlation was found for Cohort 3, $r(24) = 0.25$, $p = 0.239$. As expected, degree centrality in the personal network was positively correlated with eigenvector centrality in the personal network for Cohort 1, $r(23) = 0.68$, $p = 0.000$, and Cohort 3, $r(24) = 0.52$, $p = 0.009$. Degree centrality in the academic network was also positively correlated with eigenvector centrality in the academic network for Cohort 1, $r(23) = 0.43$, $p = 0.042$, and Cohort 3, $r(24) = 0.45$, $p = 0.026$. Eigenvector centrality in the personal network was positively correlated with eigenvector centrality in the academic network for Cohort 1, $r(23) = 0.52$, $p = 0.012$, and Cohort 3, $r(24) = 0.42$, $p = 0.042$. In Cohort 1, personal and academic networks were correlated, whereas no correlation was found between personal and academic networks in Cohort 3. Nevertheless, the network density in both the personal and academic network was higher in Cohort 3 compared to Cohort 1.

These findings can be related with the history of these networks. In Cohort 1, there was a history of relationships that had developed over a period of two semesters (i.e., SNA data collection was conducted at the end of the second semester). In Cohort 3, the history that enabled the development of personal and academic networks was only one semester (i.e., SNA data collection was conducted at the end of the first semester). In terms of the density for first semester students, the short history of their networks may not have enabled the development of clusters of personal and academic relationships, as opposed to second semester students who may have had more opportunity to first explore the whole-network and subsequently develop their own clusters within personal and academic networks. This might have contributed to the difference in density between Cohort 1 and Cohort 3. In terms of the relationship between personal and academic networks, yet another difference across cohorts was anticipated taking into consideration this historical difference. In particular, after a history of two semesters, it is highly likely that individuals in Cohort 1 who became personally connected among themselves also formed academic relationships with each other. Likewise, after a history of one semester it is highly likely that individuals in Cohort 3 were still in a network exploratory phase forming different types of relationships with different individuals. These findings reflect that personal and academic networks imply a history of relationships among individuals (Nardi et al., 2002).



(a) Cohort 3 PE-DC (b) Cohort 3 PE-EV



(c) Cohort 3 AC-DC (d) Cohort 3 AC-EV

Fig. 5. Cohort 3: degree centrality (DC) and eigenvector centrality (EV) in personal (PE) and academic (AC) networks.
Note. NC3 stands for non-CoLP3 members. C3 stands for CoLP3-members. PE-DC = degree centrality in the personal network. PE-EV = eigenvector centrality in the personal network. AC-DC = degree centrality in the academic network. AC-EV = eigenvector centrality in the academic network. The preview and layout settings on Gephi were identical for all network visualizations to avoid any visual misrepresentation of nodes' centrality.

3.2. RQ2: What is the relationship between peers' centrality in peer-feedback networks and peers' centrality in personal and academic networks?

To identify peers' centrality in peer-feedback provision networks, SNA was conducted on the basis of the video data (i.e., peer-feedback provision episodes in CEs). The peer-feedback provision networks were initially identified per CE in each CoLP and were subsequently added-up to build the peer-feedback provision network on the CoLP level, i.e. including all analyzed CEs. Four centrality measures were computed: (1) overall degree centrality, (2) out-degree centrality, (3) overall weighted degree centrality, and (4) weighted out-degree centrality. Overall degree centrality identifies peers' centrality in terms of the total number of peer-feedback connections (i.e., overall degree centrality considering both peer-feedback provision and peer-feedback reception). Out-degree centrality represents the number of the peer-feedback provision connections (i.e., out-degree centrality considering only peer-

feedback provision). Overall weighted degree centrality refers to both weighted peer-feedback provision and weighted peer-feedback reception. Finally, weighted out-degree centrality refers to the weight of peer-feedback provision connections (i.e., weighted out-degree centrality). Eigenvector centrality was also computed to identify the importance of the nodes. An overview of the centrality measures for all nodes in the personal, academic and peer-feedback network for CoLP1 is provided in Table 9 and for CoLP3 in Table 10. Nodes in Tables 9 and 10 are ordered from highest peer-feedback (overall) weighted degree to lowest peer-feedback (overall) weighted degree. The centrality measures in peer-feedback provision are visualized for CoLP1 in Fig. 6 and for CoLP3 in Fig. 7. CoLP members' centrality in Figs. 6 and 7 display a size ranking of the nodes (i.e., larger nodes represent higher centrality ranking) and with color ranking from green to pink (i.e., green nodes represent highest centrality, pink nodes lowest centrality). The directed ties in the network visualizations are weighted, representing the peer-feedback provision episodes from one node to another; or in other words, the weighted out-degree. Nevertheless, CoLP members' centrality is defined by different criteria in each visualization (i.e., overall degree centrality, overall weighted degree centrality, out-degree centrality, weighted out-degree centrality, and eigenvector centrality).

Table 9 shows the centrality measures for CoLP1 members in personal, academic and peer-feedback networks along with CoLP members' participation rate in CEs. A substantial variation in degree centralities can be observed within and across networks, especially in the centrality measures in the peer-feedback networks. The peer-feedback centrality pattern as represented in the peer-feedback network of CoLP1—based on CoLP members' degree centralities across all CEs of CoLP1—is illustrated in Fig. 6. As evident

Table 9
CoLP1: overview of all centrality measures in personal, academic, and peer-feedback networks.

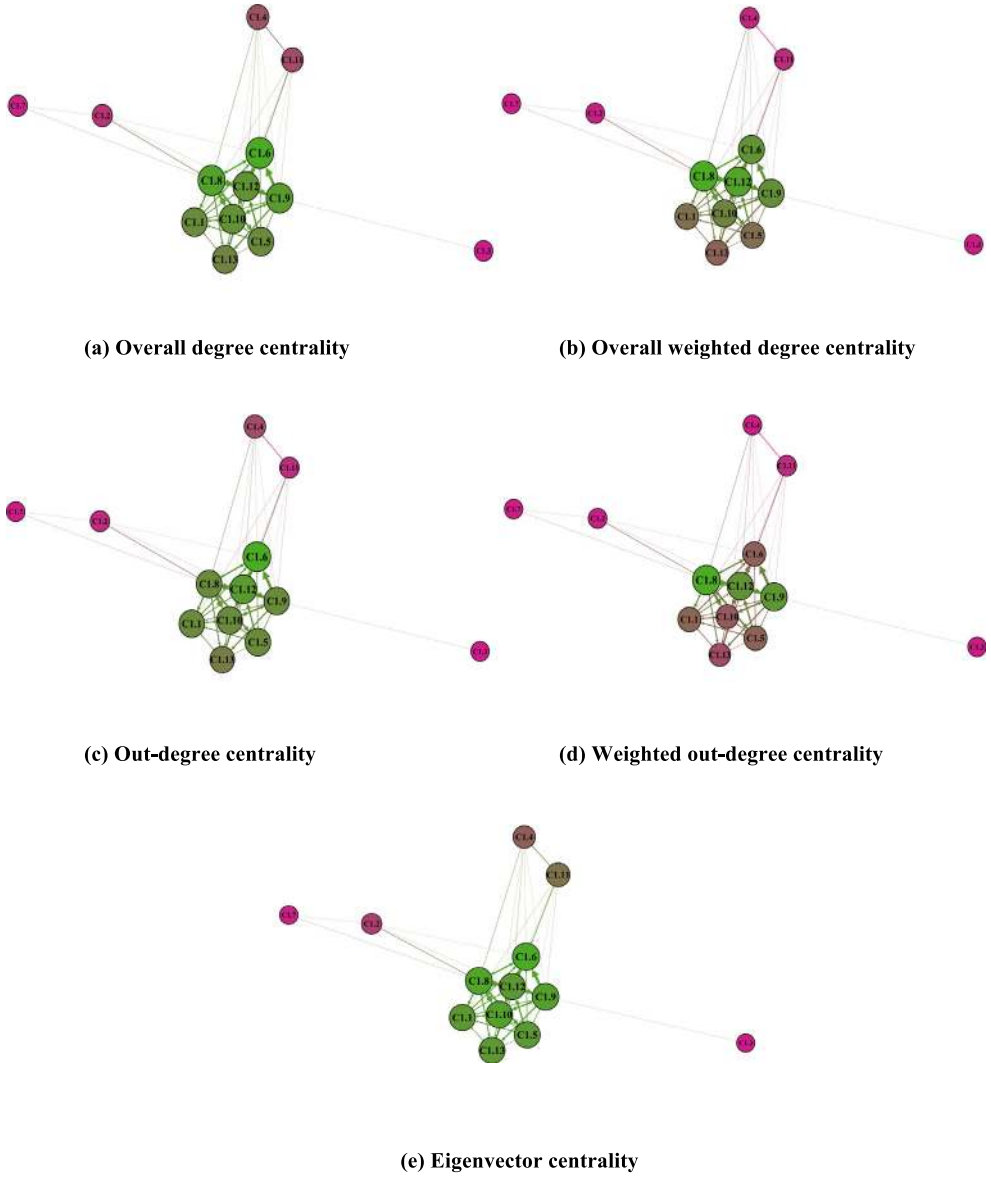
Label	P	PE degree	AC degree	PF out-degree	PF degree	PF w-out-degree	PF w-degree	EV-PF
C1.8	4	20	16	8	18	196	328	0.962
C1.12	5	24	21	9	16	162	309	0.870
C1.6	6	7	13	10	19	97	275	1
C1.9	5	19	17	8	17	169	266	0.927
C1.10	5	14	19	8	16	86	239	0.926
C1.1	3	11	11	8	15	102	194	0.870
C1.5	6	16	19	8	15	100	189	0.870
C1.13	3	20	16	7	14	69	164	0.870
C1.11	3	16	26	2	7	23	37	0.621
C1.4	5	26	25	4	8	5	28	0.468
C1.2	3	18	22	2	4	10	13	0.253
C1.7	2	17	19	1	2	3	4	0.035
C1.3	2	20	11	1	1	2	2	0.000

Note. C1 = member in CoLP1. P = participation in CEs. PE = personal network. AC = academic network. PF = peer-feedback network. EV = eigenvector centrality. EV-PF = eigenvector centrality in peer-feedback network.

Table 10
CoLP3: overview of centrality measures in personal, academic, and peer-feedback networks.

Label	P	PE degree	AC degree	PF out-degree	PF degree	PF w-out-degree	PF w-degree	EV-PF
C3.9	5	43	34	16	31	270	431	1
C3.6	6	31	18	13	26	134	232	0.907
C3.17	5	26	19	9	21	86	299	0.857
C3.4	4	26	28	10	18	120	202	0.581
C3.13	2	24	30	10	16	123	193	0.486
C3.16	4	21	20	10	19	92	154	0.613
C3.2	5	37	27	11	21	75	147	0.671
C3.10	5	24	22	12	22	46	142	0.715
C3.12	4	18	25	5	18	35	136	0.950
C3.5	4	33	8	11	19	53	118	0.590
C3.15	2	20	22	3	14	20	104	0.812
C3.1	4	21	15	7	15	48	95	0.635
C3.18	4	22	19	6	11	37	81	0.348
C3.8	4	17	27	9	12	56	69	0.230
C3.11	4	25	25	7	11	31	44	0.318
C3.14	6	23	24	2	6	14	37	0.256
C3.3	3	25	23	1	7	8	20	0.478
C3.7	2	17	20	3	3	8	8	0.000
C3.19	2	10	14	0	0	0	0	0.000

Note. C3 = member in CoLP3. P = participation in CEs. PE = personal network. AC = academic network. PF = peer-feedback network. EV = eigenvector centrality. EV-PF = eigenvector centrality in peer-feedback network.



(a) Overall degree centrality

(b) Overall weighted degree centrality

(c) Out-degree centrality

(d) Weighted out-degree centrality

(e) Eigenvector centrality

Fig. 6. CoLP1: centrality measures in peer-feedback provision networks across CEs.
Note. C1 = CoLP1 members. Network density: 0.487.

in Table 9 and Fig. 6, all CoLP1 members appear in the network, implying that all CoLP members provided peer feedback—at least once. Fig. 6 reveals that some of the CoLP1 members with the highest peer-feedback overall degree centrality (i.e., C1.8, C1.9, C1.12) and the lowest peer-feedback overall degree centrality (i.e., C1.3, C1.7) retain their positioning across centrality measures, whereas all other CoLP1 members slightly change positioning across these measures (i.e., moving from core to periphery and from periphery to core).

Table 10 shows the centrality measures for CoLP3 members in personal, academic and peer-feedback networks along with CoLP members' participation rate in CEs. It can be observed that there is substantial variation in degree centralities within and across networks, and especially in the centrality measures in the peer-feedback networks, as also observed in CoLP1. The peer-feedback centrality pattern as represented in the peer-feedback network of CoLP3—based on CoLP members' degree centralities across all CEs of CoLP3—is illustrated in Fig. 7. As evident in Fig. 7, 18 out of 19 CoLP3 members appear in the network, since C3.19 did not engage into a peer-feedback provision episode in CoLP3. CoLP3 members' centrality in Fig. 7 is represented with the same ranking attributes as CoLP1 members' centrality in Fig. 6. Fig. 7 reveals a greater variability in CoLP3 members' centrality positioning across measures, with only C3.9 (i.e., highest peer-feedback overall degree centrality) and C3.7 (i.e., lowest peer-feedback overall degree centrality) to retain the same positioning across centrality measures. All other CoLP3 members seem to change centrality positioning across centrality measures with high variability.

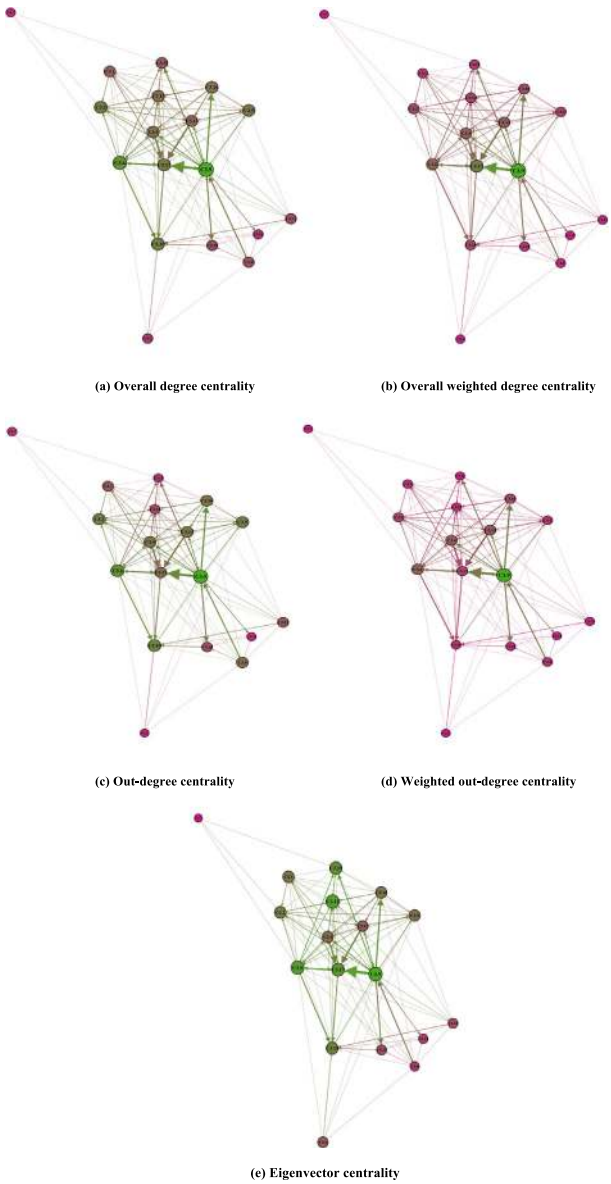


Fig. 7. CoLP3: centrality measures in peer-feedback provision networks across CEs.
Note. C3 = CoLP3 members. Network density: 0.424.

A further exploration into CoLP members' centrality across measures and networks from a quantitative perspective was considered relevant to address RQ2. Spearman correlations were calculated to assess the relationships between peers' centrality in peer-feedback networks—i.e., (a) overall degree centrality in peer-feedback networks, (b) out-degree centrality in peer-feedback networks, (c) overall weighted degree centrality in peer-feedback networks, (d) weighted out-degree centrality, and (e) eigenvector centrality—and personal and academic networks—i.e., (a) overall degree centrality and (b) eigenvector centrality. Table 11 reports the correlations for Cohort 1/CoLP1 and Cohort 3/CoLP3.

Table 11 is revealing in several ways. First, it shows the correlational pattern of CoLP members centrality on the Cohort/CoLP level, and second enables a comparative view across Cohorts/CoLPs. For Cohort1/CoLP1, multiple strong positive correlations were found between peer-feedback degree centrality, peer-feedback out-degree centrality, peer-feedback eigenvector centrality, and participation in CEs. A moderate positive correlation was found between peer-feedback weighted degree and participation in CEs. Although not significant, the direction of the correlation of most peer-feedback centrality measures with degree and eigenvector

Table 11
Correlations between peers' centrality in peer-feedback, personal and academic networks.

	PF degree	PF out-degree	PF w-degree	PF w-out-degree	PF-EV
Cohort 1/CoLP1 (N = 13)					
PE degree	−0.22	−0.25	−0.11	−0.10	−0.31
PE-EV	−0.17	−0.10	−0.12	0.01	−0.20
AC degree	−0.26	−0.23	−0.19	−0.22	−0.31
AC-EV	0.13	0.27	0.18	0.19	0.13
Participation in CEs	0.75**	0.80**	0.65*	0.55	0.69**
Cohort 3/CoLP3 (N = 19)					
PE degree	0.67**	0.68**	0.63**	0.59**	0.48**
PE-EV	0.50**	0.38	0.54*	0.44	0.54*
AC degree	0.14	0.21	0.27	0.31	0.09
AC-EV	0.74**	0.65**	0.74**	0.62**	0.72**
Participation in CEs	0.61**	0.55*	0.49*	0.45	0.47*

Note. PE = personal network. AC = academic network. PF = peer feedback. EV = eigenvector centrality. PE-EV = eigenvector centrality in personal network. AC-EV = eigenvector centrality in academic network. w- = weighted, PF-EV = eigenvector centrality in peer-feedback network.
* $p < 0.05$.
** $p < 0.01$.

centrality in the personal network and degree centrality in the academic network, is negative. A different correlational pattern is observed for Cohort3/CoLP3. Peer-feedback degree, peer-feedback out-degree, peer-feedback weighted degree, peer-feedback weighted out-degree and eigenvector centrality were all strongly and positively correlated with degree centrality in the personal network and eigenvector centrality in the academic network.

Findings on the CoLP level underscore that peer-feedback provision constitutes a relational learning practice and that peer-feedback providers' centrality in personal networks is to some degree reflected in their centrality in the peer-feedback provision networks, whereas peers' centrality in academic networks is less reflected in their centrality in the peer-feedback provision networks. In addition, it can be argued that the examined CoLPs served indeed as peer support mechanisms for CoLP members (e.g., social support, academic support, personal development support) and provided the social infrastructure that afforded the active engagement of CoLP members—to a different extent—in peer interactions in general (e.g., information sharing, experience sharing) and in peer-feedback interactions in particular in response to their and others' common and/or individual needs framed within their personal and academic networks. As also indicated by the peer-feedback scenery of each CoLP the social structures of peer-feedback interactions—in terms of peer-feedback provision—were re-recombinant social structures, sometimes monitored by the participatory facilitator, especially at the early stages of CoLP development to foster and establish a peer-feedback culture, and sometimes emergent by CoLP members' own initiatives for feedback seeking and feedback provision. Therefore, interpretations based solely on the peer-feedback centrality of CoLP members should be treated with caution.

3.3. RQ3: What are the types and focus of peer-feedback provision episodes in CoLPs?

The content analysis revealed a similar pattern of provided peer-feedback types and foci across CoLPs (see Tables 12 and 13). The findings showed that – across CEs in both CoLPs – *Verification positive* was the most frequently provided type of peer feedback (CoLP1: 40.63%; CoLP3: 42.28%), followed by *Argumentation* (CoLP1: 26.27%; 28.42%) and *Suggestion* (CoLP1: 13.28%; CoLP3: 15.84%). In terms of the peer-feedback focus, the majority of the peer-feedback provision segments addressed skill-, task-, or performance-related aspects (CoLP1: 72.27%; CoLP3: 70.46%) followed by personal aspects (CoLP1: 17.77%; CoLP3: 18.71%) and study-related aspects (CoLP1: 9.47%; CoLP3: 7.80%). Peer-feedback focused on social engagement and contribution to social activities was rarely observed (CoLP1: 0.49%; CoLP3: 3.03%), although this aspect was more evident in CoLP3.

Turning now to how the types and foci of peer-feedback provision statements were distributed across participants, it is apparent from Figs. 8 through 11 that the distribution varied substantially, although the type *Verification positive* and the focus *Skill* were dominant across the majority of participants in both CoLPs. As observed in the figures, CoLP3 members seem to have used a larger variety of feedback types and foci compared to CoLP1.

The variety of the commented aspects (i.e., skill, personal, social, study) highlights the multidimensionality of the peer-feedback interactants' relationships (e.g., classmates, presenter's audience, friends, work group collaborators) and reveals all interwoven aspects of these relationships. This observation is in line with the multiplexity of ties (Katz et al., 2004), which is reflected in the focus of the provided peer feedback. CoLP members may simultaneously be connected with state-ties and event-ties, or in Granovetter's terminology with strong and weak ties, which can in turn affect the content of the peer-feedback provision episodes.

Table 12
CoLP1: peer-feedback scenery.

CE	Feedback seekers	Initiative/intervention	PF activity	PF Eps.	% PF Eps.	Content analysis					
						Level 1: type			Level 2: focus		
						Code	*f*	%	Code	*f*	%
CE1.1	C1.4, C1.8	Random selection by facilitator	Spontaneous/ unprepared presentation (Pecha Kucha)/discussion about presentation skills	36	3.52%	Verification positive Argumentation Verification negative Suggestion Affect: effort acknowledgement	15 15 3 2 1	41.67% 41.67% 8.33% 5.56% 2.78%	SK	36	100%
CE1.2	C1.9, C1.11, C1.7, C1.6, C1.2, C1.12	Random selection by facilitator	Spontaneous/ unprepared presentation with instant feedback cards	23	2.25%	Suggestion Affect: support/ encouragement Argumentation Verification negative	11 8 3 1	47.83% 34.78% 13.04% 4.35%	SK PE ST	14 5 4	60.87% 21.74% 17.39%
CE1.3	C1.12, C1.9, C1.10	Members' self-initiated exposure	Members' presentations/ discussion about presentation design	114	11.13%	Suggestion Verification positive Argumentation Verification negative Question	47 30 16 15 6	41.23% 26.32% 14.04% 13.16% 5.26%	SK	114	100%
CE1.4	C1.9, C1.11	Members' self-initiated exposure	Members' presentations/ discussion about presentation styles/ design	34	3.32%	Verification positive Argumentation Suggestion Verification negative Affect: support/ encouragement	10 10 9 3 2	29.41% 29.41% 26.47% 8.82% 5.88%	SK	34	100%
CE1.5	C1.9, C1.8	Members' self-initiated exposure	In-community created posters/discussion about poster presentation styles	24	2.34%	Verification positive Argumentation Suggestion Verification negative	7 7 6 4	29.17% 29.17% 25.00% 16.67%	SK	24	100%
CE1.6	C1.1, C1.5, C1.6, C1.8, C1.9, C1.10, C1.12, C1.13	Facilitator's initiative on members' self-reflection/ spontaneously switch to a global PF session	Self-reflection/global PF session	793	77.44%	Verification positive Argumentation Verification negative Suggestion Affect: effort acknowledgement Affect: support/ encouragement Question	354 218 67 61 54 29 10	44.64% 27.49% 8.45% 7.69% 6.81% 3.66% 1.26%	SK PE ST SO	518 177 93 5	65.32% 22.32% 11.73% 0.63%
CE1.1–CE1.6				1024	100%	Verification positive Argumentation Suggestion Verification negative Affect: effort acknowledgement Affect: support/ encouragement Question	416 269 136 93 55 39 16	40.63% 26.27% 13.28% 9.08% 5.37% 3.81% 1.56%	SK PE ST SO	740 182 97 5	72.27% 17.77% 9.47% 0.49%

Note. CE1 = community event in CoLP1. PF = peer feedback. Eps = episodes. SK = skill. PE = personal. ST = study. SO = social. The identified types and foci in the content analysis section of the table are presented in rank-order position from the most frequently occurring one to the least frequently occurring.

Table 13
CoLP3: peer-feedback scenery.

CE	Feedback seekers	Initiative/intervention	Main PF activity	PF Eps.	% PF Eps	Content analysis					
						Level 1: type			Level 2: focus		
						Code	*f*	%	Code	*f*	%
CE3.1	C3.2, C3.10, C3.15	Random facilitator's selection/members gave feedback only to same-group members	Spontaneous/ unprepared presentation (Pecha Kucha)/discussion about presentation skills	64	5.10%	Argumentation	19	29.69%	SK	64	100%
						Verification positive	18	28.13%			
						Affect: effort	14	21.88%			
						acknowledgement	7	10.94%			
						Verification	4	6.25%			
						negative	2	3.13%			
						Suggestion					
						Affect: Support/ encouragement					
CE3.2	C3.3, C3.5, C3.8, C3.4, C3.11, C3.16, C3.9, C3.6	Random facilitator's selection/feedback seeker initiated feedback discussion at the end of the CE with only with two other members	Spontaneous/ unprepared presentation/ discussion about presentation skills	123	9.79%	Verification positive	56	45.53%	SK	116	94.31%
						Argumentation	31	25.20%	PE	5	4.07%
						Suggestion	21	17.07%	ST	2	1.63%
						Affect: support/	6	4.88%			
						encouragement	4	3.25%			
						Affect: effort	4	3.25%			
						acknowledgement	1	0.81%			
						Verification					
						negative					
						Question					
CE3.4	C3.12, C3.18, C3.10	Members' self-initiated exposure/feedback session focused on C3.10's presentation as discussion springboard	Self-initiated past and in-progress presentations	125	9.95%	Argumentation	47	37.60%	SK	99	79.20%
						Suggestion	31	24.80%	ST	26	20.80%
						Verification positive	22	17.60%			
						Affect: support/	11	8.80%			
						encouragement	11	8.80%			
						Verification	3	2.40%			
						negative					
						Question					
CE3.5	C3.9, C3.18, C3.14	Members' self-initiated exposure	Self-initiated in-progress motivation letters and CVs	124	9.87%	Suggestion	53	42.74%	SK	122	98.39%
						Argumentation	37	29.84%	PE	2	1.61%
						Verification positive	17	13.71%			
						Question	6	4.84%			
						Affect: support/	3	2.42%			
						encouragement	3	2.42%			
						Affect: interest	3	2.42%			
						Verification	2	1.61%			
						negative					
						Affect: effort acknowledgement					
CE3.7	C3.1, C3.2, C3.4, C3.5, C3.6, C3.9, C3.12, C3.13, C3.15, C3.16, C3.17	Facilitator's invitation for peer-feedback exchange (feedback focus: open to members' interests)	Global feedback session	820	65.29%	Verification positive	418	50.98%	SK	484	59.02%
						Argumentation	223	27.20%	PE	228	27.80%
						Suggestion	90	10.98%	ST	70	8.54%
						Affect: support/	43	5.24%	SO	38	4.63%
						encouragement	33	4.02%			
						Verification	11	1.34%			
						negative	2	0.24%			
						Affect: effort acknowledgement					
						Question					
CE3.1–C3.7				1256	100%	Verification positive	531	42.28%	SK	885	70.46%
						Argumentation	357	28.42%	PE	235	18.71%
						Suggestion	199	15.84%	ST	98	7.80%
						Affect: support/	65	5.18%	SO	38	3.03%
						encouragement	58	4.62%			
						Verification	31	2.47%			
						negative	12	0.96%			
						Affect: effort acknowledgement	3	0.24%			
						Question					
						Affect: interest					

Note. CE3 = community event in CoLP3. PF = peer feedback. Eps = episodes. SK = skill. PE = personal. ST = study. SO = social. The identified types and foci in the content analysis section of the table are presented in rank-order position from the most frequently occurring one to the least frequently occurring.

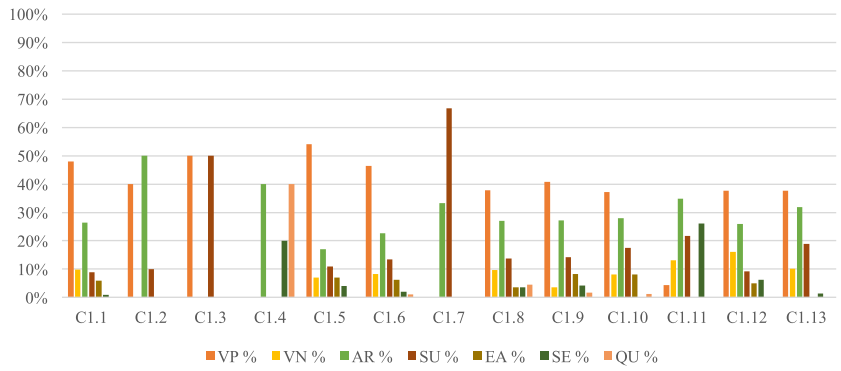


Fig. 8. CoLP1: peer feedback provision types per participant.
Note. CoLP1 = community of learning practice 1. VP = verification positive. VN = verification negative. AR = argumentation. SU = suggestion. EA = affect: effort acknowledgement. SE = affect: support/encouragement. QU = question.

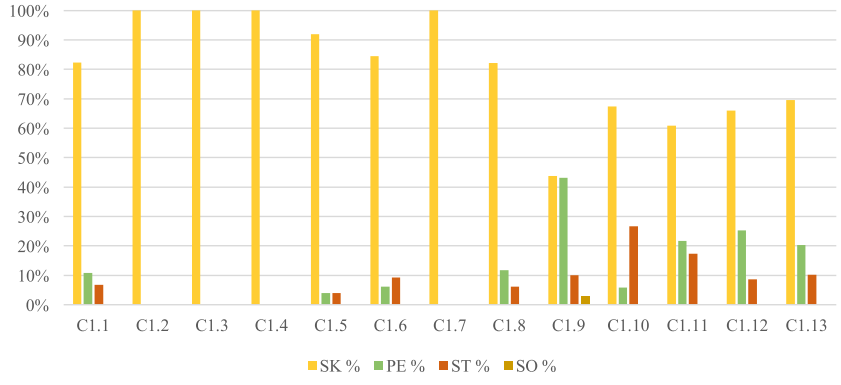


Fig. 9. CoLP1: peer feedback provision foci per participant.
Note. CoLP1 = community of learning practice 1. SK = skill. PE = personal. ST = study. SO = social.

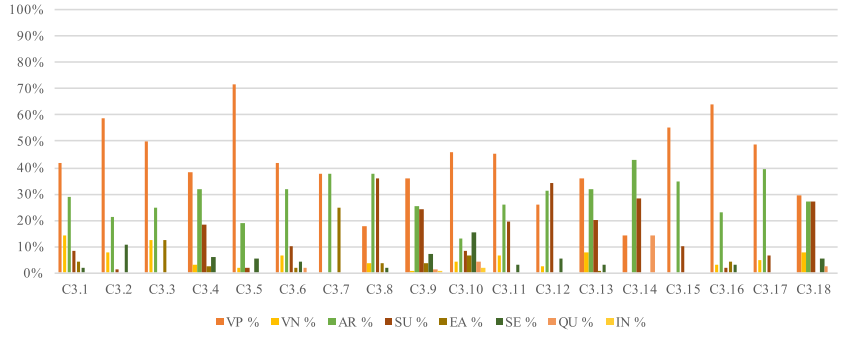


Fig. 10. CoLP3: peer feedback provision types per participant.
CoLP3 = community of learning practice 3. VP = verification positive. VN = verification negative. AR = argumentation. SU = suggestion. EA = affect: effort acknowledgement. SE = affect: support/encouragement. QU = question.

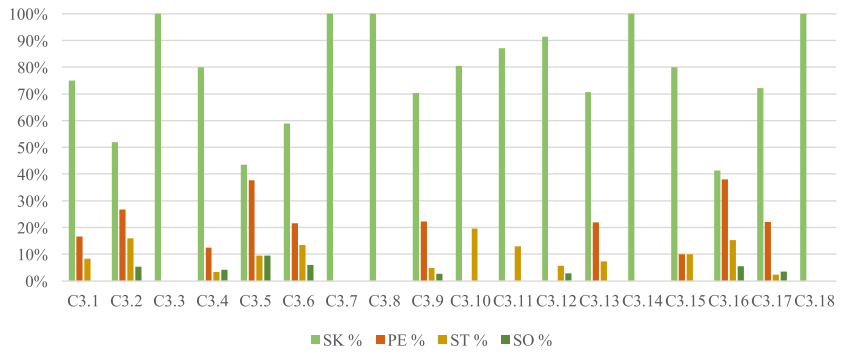


Fig. 11. CoLP3: peer feedback provision foci per participant.
Note. CoLP1 = community of learning practice 1. SK = skill. PE = personal. ST = study. SO = social.

4. Methodological limitations

To begin with, the variability in members' participation rate in CEs, which was to be expected within a real life non-controlled research context, resulted into missing data that may have contributed to misrepresentation of network data that were extracted from the video recordings. CoLP members who did not frequently attend the CEs may have been exposed to fewer opportunities to engage in peer-feedback provision processes. Additionally, both random and self-initiated exposure to peer-feedback seeking resulted to a limited number of peer-feedback recipients, which may have affected the peer-feedback provision process as well.

In terms of missing data in the SNA, students who did not fill out the network questionnaire – regardless of whether they were community members or not – were eliminated from the network sample to avoid any (a) ethical concerns (i.e., students not included as a node if they did not complete the questionnaire) and (b) structural problems caused by nodes appearing as nominees, but missing as nominators. Therefore, missing data were not imputed. In Cohort 1, data were missing exclusively for non-community members (3 non-community members), whereas in Cohort 3, data were missing for both community (3 members) and non-community members (2 members). However, irrespective of these arguments the elimination of nodes from the network sample has its own deficiencies, including possible data distortion and a smaller network (see Borgatti & Molina, 2003; Kossinets, 2006).

Another possible source of error is the dominance of peer-feedback episodes evident in the last CEs of both CoLPs, which may have affected the centrality measures in peer-feedback networks based on the analysis of the video recordings. CoLP members who did not attend the last CEs (i.e., CE1.6 and CE3.7; Global peer-feedback sessions) may have been ranked lower in the degree centrality measures of the peer-feedback networks. Furthermore, reactivity might have influenced the peer-feedback interactions. As argued by Knoblauch et al. (2012), the presence of video cameras in the CoLP setting may have influenced the peer-feedback provision types or other aspects of the peer-feedback interactions in unforeseeable ways.

The complexity of conducting SNA within an MMR analysis framework resulted into a remarkably labor-intensive analysis and high complexity in reporting and visualizing the findings, constituting this approach a challenging and ambitious endeavor. Adding to this complexity, the use of video data, irrespective of being one of the richest forms of data in the social sciences, are still highly complex when it comes to their analysis (Knoblauch et al., 2012), in particular from an SNA perspective. More systematic methodological advancements are required to simplify the integration of MMR into SNA-oriented studies.

Last but not least, considering the researcher's role as the participatory facilitator in the CEs of both CoLPs, an unintended bias cannot be ruled out. Additionally, the activities initiated by the participatory facilitator might have affected the actions and behavior of the CoLP members towards different and unpredictable directions. Nevertheless, the systematic analysis that involved coders that were external to both CoLPs, addressed this issue and decreased (or even eliminated) bias to the extent possible.

5. Implications

This section presents the theoretical, methodological, and practical implications of this study. Suggestions for future research are included in each subsection since this study serves as a springboard for further investigation on social network aspects of peers (e.g., centrality across social networks), who engage in peer-feedback interactions in learning communities and/or other social learning structures in higher education that enable them.

5.1. Theoretical implications

This study has strengthened the argument that peer feedback in higher education has the potential to escape mere traditional assessment practices towards authentic learning experiences, which utilize peer feedback as a sharing mechanism and learning practice. More specifically, based on the findings reported in this paper, peer feedback in higher education (if properly implemented) has its own place not just in students' learning, but also in students' multidimensional social experiences of learning with peers. Whether this sharing mechanism succeeded in developing into a learning mechanism (i.e., way in which learning comes about) (see

Lave, 1996) should not and was not taken for granted. In other words, whether learning came about through the mechanism of peer feedback was not validated in this study.

Additionally, this study has highlighted the multiplexity and complexity of peer-feedback interactions in higher education, considering that peer-feedback providers are connected or not to each other with multiple types of relationships/ties (i.e., personal, academic), which may in turn enable or hinder peer-feedback provision differently (i.e., types, foci of peer feedback). Future research on nested peer-feedback interactions in higher education (or adult learning in general) needs to be undertaken to determine more precisely the ways in which centrality in surrounding networks affects the peer-feedback interactions, also by taking into consideration the peer-feedback response aspect (i.e., acceptance or rejection by the recipient and resulting (inter)actions).

5.2. Methodological implications

A mixed-methods approach to SNA has the potential to capture the complexity of multiplex networks across levels (i.e., cohort and CoLP level), at least to an extent that provides not merely structural information about the networks of interest, but also the content and context of the formed ties within these structures—in line with Crossley's (2010) and De Laat and Strijbos' (2014) suggestion to consider the content of ties in social networks and De Laat et al.'s (2007) multi-method framework for examining social learning networks. CoLP members may engage in peer-feedback interactions and thus forming peer-feedback networks. Examining only the network structure does not provide much information about the content that these interactions carry along. Nevertheless, the content is an inherent element of these social interactions, and its investigation is vital for understanding them (Crossley, 2010).

This study further contributes to research efforts that argue for the consideration of degree centrality as well as weighted degree centrality when examining centrality of nodes in social networks (Opsahl et al., 2010). Future work that examines the relationship between weighted event ties (e.g., peer-feedback networks) and multiplexity of state ties – while considering the content of the ties – is recommended to establish whether a relationship exists on the tie level. Nevertheless, it should be highlighted that an investigation of this kind is highly complex when approached from an MMR perspective.

5.3. Practical implications

The present findings have demonstrated that peer feedback is an inherent element of CoLPs, and potentially of other similar social learning support structures alike. Furthermore, peers engaged in peer-feedback interactions on various feedback types and foci, while being free from any expertise or assessment expectations or comparisons to expert's feedback. Educators and community facilitators should take into consideration the multiplex nature of peer feedback and acknowledge and foster students' engagement in peer feedback as an inherent element of any social learning situation, within which students can be friends, classmates, locals or foreigners, members of the same presentation group, or simply social interactants in an interpersonal communication situation.

6. Conclusion

The present study investigated peers' centrality across social networks, i.e. peer-feedback provision networks enabled by CoLP participation, and personal and academic networks, along with the type and focus of the provided peer feedback. Social networks were investigated on the cohort level (i.e., personal and academic networks) and on the CoLP level (i.e., peer-feedback provision networks). From a social network perspective on learning and while moving beyond the association of peer feedback with traditional assessment practices (e.g., Boud, 2000; Falchikov, 2005; Nicol, 2013), this study approached and investigated peer feedback in higher education as a communicative network nested in personal and academic social networks, and as a relational and dialogical process that is socially mediated and inherent in social learning situations (Haythornthwaite, 2008; Strijbos & Müller, 2014). Peer-feedback provision networks were enabled by participation in CoLPs on the micro-level and in the broader socio-educational context(s) on the macro-level. This perspective on peer feedback closely resembles the "feedback reality" in any professional or other learning settings that moves beyond traditional assessment. Participants' centrality measures were considered in the peer-feedback networks (on the CoLP level) and in the surrounding social networks (on the cohort level) to address the research gap in the role of peers as social actors in social networks that surround and transcend peer-feedback interactions and subsequently the role of these networks in peer-feedback interactions. In closing, this study supports the argument that the examination of social network structures consitutes a prerequisite for comprehending how learners engage with each other in peer-feedback provision interactions inherent in an ongoing process of community building (e.g., Haythornthwaite, 2008).

Declarations of interest

None.

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