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Student participatory role profiles in collaborative science learning: Relation of within-group configurations of role profiles and achievement

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ABSTRACT

During collaborative learning, students tend to spontaneously enact different participatory roles that may significantly affect collaborative learning processes. Only few empirical studies to date have investigated groups as systems based on emerging roles and role profiles of the participating students, and how emerging role profile configurations affect achievement. This exploration of students' self-adopted roles investigated the relationship between role profile configurations and achievement. The statistically driven identification of role profiles was based on fine-grained observations of student groups' interactions in two distinct collaborative science-learning settings. While higher achieving groups typically exhibited versatile science-oriented role profile configurations, opinion-based configurations prevailed in lower achieving groups. Although role profiles with a social orientation were rare, a student with a distracting profile can have a significant influence on group work. Consolidated by in-depth case examples, the findings highlight the importance of understanding how collaborating groups' emergent role profiles dynamically interact during collaborative learning and how different role profile configurations relate to achievement.

1. Introduction

Collaborative learning is widely considered to offer potential individual learning gains (see Chen, Wang, Kirschner, & Tsai, 2018; Springer, Stanne, & Donovan, 1999), as well as valuable experience of working successfully and productively with others toward a common goal, which has become increasingly important in the twenty-first century (OECD, 2019). Previous studies have sought to understand "when and why groups fail and when and why they succeed" (Nokes-Malach, Richey, & Gadgil, 2015, p. 678) in their collaborative learning effort by looking at multiple issues that include, for instance, productive interactions and contributions (e.g., Barron, 2003; Isohätälä et al., 2018); interpersonal regulatory processes (e.g., Ucan & Webb, 2015; Volet & Vauras, 2013); and disciplinary engagement (e.g., Engle & Conant, 2002; Sinatra, Heddy, & Lombardi, 2015). However, despite the known importance of roles in human interaction (Hare, 1994), few empirical studies have addressed how the participatory roles adopted by group members

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during collaboration influence learning processes and outcomes.

There is some evidence that pre-assigned roles can promote high-quality collaborative learning. This popular educational practice seeks to scaffold and structure meaningful collaborative learning processes by assigning specified roles to group members (Strijbos & Weinberger, 2010). To date, however, only a limited number of studies have examined the significance of non-assigned or self-adopted roles that emerge spontaneously during socially-shared learning activities (Hogan, 1999; Stempfle, Hübner, & Badke-Schaub, 2001; Strijbos, Martens, Jochems, & Broers, 2007; Volet, Jones et al., 2019; Volet et al., 2017). We contend here that the multiple self-adopted roles enacted during collaborative learning tend to form patterns and clusters that constitute individual role profiles. To explore this idea, the present study investigated the emergence of student role profiles in real-world collaborative science learning, and how different within-group configurations of role profiles relate to achievement.

1.1. Roles in collaborative learning

Collaborative learning groups are typically formed without predefining individual tasks and responsibilities (Kirschner & Erkens, 2013), affording students equal opportunities for participation by allowing them to adopt self-enacted roles without formal restrictions. As contemporary perspectives on collaborative learning emphasize its complex, emergent, interactive, and dynamic nature (Hilpert & Marchand, 2018; Jacobson, Kapur, & Reimann, 2016; Marchand & Hilpert, 2020; Zuiker, Anderson, Jordan, & Stewart, 2016), excessive scripting may indeed interfere with natural processes of collaboration (Dillenbourg, 2002). In any event, the practical reality is that students do not necessarily adhere to scripted roles; for that reason, it can be argued that research should devote more attention to emergent and self-enacted roles in collaborative learning settings (see Oliveira, Boz, Broadwell, & Sadler, 2014).

The multiple distinct roles that emerge during group activities reflect their contextual and situated nature (see Driskell, Driskell, Burke, & Salas, 2017). While these roles have been conceptualized and operationalized in various ways, it is widely accepted that most can be characterized as either *task-related* or *socio-emotional* (Forsyth, 2014). Task roles relate to required inputs for task completion, and socio-emotional roles relate to group-building, which may be hindered by individual divergence from group needs and goals (Benne & Sheats, 1948, 2007). In their review of the collaborative learning literature, Strijbos and De Laat (2010) identified three distinct approaches: role as task (micro-level), role as pattern (*meso*-level), and role as stance (macro-level). At the micro level, roles relate to the individual contributions and behaviors that unfold during social interaction. Heinimäki et al., 2020) coined the term *functional participatory roles* to refer to this level and demonstrated how these roles can change constantly during the course of a collaborative activity. The meso level refers to patterns of participatory roles that develop over time from the micro level to form role profiles (Strijbos & De Laat, 2010; see also Hogan, 1999). With regard to the macro level, Strijbos and De Laat (2010) suggested that this "provides a more contextual understanding of how tasks and patterns at the micro- and meso-level will be carried out" (p. 497), including personal attitudes and orientations to collaboration and the learning task.

While micro-level analysis is essential when tracing role emergence and evolution in social interaction, it is equally important to identify meso-level role profiles, as recurring individual behaviors and patterns can be expected to have a stronger impact than singular acts or roles alone (Lehmann-Willenbrock, Beck, & Kauffeld, 2016). To date, however, empirical studies have focused exclusively on the micro level (e.g., Volet, Jones et al., 2019; Volet et al., 2017), and any identification of broader patterns has not generally been anchored by detailed micro-level observations (e.g., Hogan, 1999; Richmond & Striley, 1996). Some studies have also used questionnaires (e.g., Meslec & Curşeu, 2015) or post hoc peer evaluation methods (e.g., Mudrack & Farrell, 1995), neither of which is sufficiently sensitive to capture the dynamic and interactive aspects of participatory roles and role profiles. The systematic analytical method adopted in the present study addresses these deficits by emphasizing the multilevel nature of roles. Based on fine-grained observations of emergent functional participatory roles at the micro level, the statistically driven identification of role profiles at the *meso* level in the present study offers new empirical and methodological insights.

1.2. Roles and achievement in collaborative science learning

Roles are a significant aspect of high-quality collaborative learning processes and outcomes (Hoadley, 2010; Katz & Kahn, 1978; Kozlowski & Ilgen, 2006). The roles enacted during group activities illuminate individuals' engagement with the task and with their peers (Volet, Jones et al., 2019). Although fundamentally individual, roles in social contexts are always intertwined with other individuals (Humphrey, Morgeson, & Mannor, 2009; Stewart, Fulmer, & Barrick, 2005). To date, however, few studies have investigated how roles support or hinder group goal attainment (Lehmann-Willenbrock et al., 2016), and it remains unclear how individual roles within the group interact and combine during collaborative learning and how this is reflected in learning outcomes (Dowell, Nixon, & Graesser, 2019).

In an observational study of eighth grade collaborative science activities, Hogan (1999) identified eight different role profiles enacted in the groups and referred to these in comparing the quality of scientific reasoning in each group. Hogan noted that reasoning was enhanced by, for example, *content knowledge contributors* and *reflection promoters*, and impeded by, for example, *distraction promoters* and *simple task completion promoters*. The study was the first to highlight the impact of distractor roles, previously unscrutinized in the assigned roles studies (Oliveira et al., 2014). Maloney (2007) also reported an association between primary school science students' participatory roles and group skill in utilizing scientific evidence for collaborative decision making. In that study, the group with the greatest number of positive roles (e.g., Information Manager, Idea Promoter) proved most skilled in applying scientific evidence during the decision-making process. In contrast, groups with fewer positive roles and those with more negative roles (e.g., Distracter, Reticent) proved less successful in that regard. In their study of veterinary students, Volet et al. (2017) found that groups that enacted roles involving higher levels of cognition (i.e., knowledge- and information-based roles) were able to build more scientifically accurate concept maps of clinical cases than groups characterized by lower level opinion-based roles. Additionally, students in the higher-achieving groups showed greater variation and flexibility in enacting their different roles than those in the lower-achieving groups.

1.3. Aims and research questions

The main aim of the present study was to investigate self-adopted participatory roles and role profiles in collaborative science learning and their relation to achievement. To that end, we first employed clustering methods to identify student *role profiles* from micro-discursive observational analysis of the discrete functional participatory roles enacted by students during collaborative activity. We then compared within-group configurations of role profiles in higher- and lower-achieving groups, using two separate data sets from authentic contexts for a wider perspective. The study addressed two main research questions.

RQ1. *What distinct student role profiles can be identified from the discrete functional participatory roles spontaneously enacted during collaborative learning activities?*

RQ2. *How do higher- and lower-achieving groups differ in terms of within-group role profile configurations?*

Given the context- and activity-specific nature of roles (Heinimäki et al., 2020; Driskell et al., 2017) and the lack of prior studies based on discrete role observations and clustering methods, we could only proceed on the basis of general expectations rather than specific predictions. However, some earlier research informed those expectations; in particular, we anticipated 1) that student role profiles in higher-achieving groups would be more science-oriented and would make a more positive contribution (Hogan, 1999; Volet et al., 2017) and 2) that profiles in higher-achieving groups would be more versatile (Maloney, 2007; Volet et al., 2017).

2. Method

2.1. Research sites and group activities

Both data sets relate to an inquiry-based science activity undertaken in small groups. The first case involved senior high school general science students from Finland (referred to hereafter as *high school students*), who completed a computer-supported activity (see Heinimäki et al., 2020; Vauras et al., 2019; Pietarinen et al., 2019). The second case involved first-year preservice student primary teachers from Australia (referred to hereafter as *teacher education students*), who completed a 'hands-on' activity (see Pino-Pasternak & Volet, 2018; Volet, Jones et al., 2019; Volet, Seghezzi et al., 2019). The group activities were undertaken in real classroom settings and were designed to promote conceptual understanding and scientific investigation skills—in other words, to cultivate both "thinking" and "doing" aspects of learning science (see Furtak & Penuel, 2019). The activities included planning, experimenting, and concluding a scientific inquiry, which the group members were expected work collaboratively and without prescribed roles. Although allowing students some authority and freedom, the activities were only partly student-led in the sense that they were specified and monitored by their teachers, who could provide assistance if needed. In the case of the Australian teacher education students, the groups were self-formed, although this process was somewhat random, as this was a first-year introductory course and the students did not know each

Table 1
Summary details of the two data sets.

Country Data type	Education level Site Group composition	Environment Resources	Activity Selected task phases	Identification of higher- and lower-achieving groups
Finland Videos & transcripts	High school (16–17 yrs., mostly 17 yrs) Advanced-level biology and chemistry courses Groups: 3 females (×2); 3 males; 2 females +1 male	Virtual laboratory Laptop, laboratory-based reading and tools, Internet	Activity: ViBSE research project—virtual learning environment for exploring the effects of pH changes on reproduction of certain animal planktons living in the Baltic Sea Phase 1 (planning): Plan study and generate a hypothesis Phase 2 (concluding): Analyze experimental results, draw conclusions, and prepare PowerPoint presentation of research project	Quality of achievement assessed on the basis of group PowerPoint presentation Presentations independently assessed by two science professionals as high-, average-, or low-achieving in terms of quality of scientific language, hypothesis, and conclusions
Australia Videos & transcripts	Teacher education students (17–35 yrs., mostly 17–25 yrs) Introductory science course Groups: 4 females (×3); 4 males	Hands-on inquiry Everyday household materials, lecture notes, relevant science readings	Activity: Research project on chemical reactions in small "rockets" using materials provided. Phase 1 (planning): Plan study, generate hypothesis, and select materials for the experiment Phase 2 (concluding): Analyze experimental results and draw conclusions	Quality of achievement based on individual marks in final course exam All members of a given group performed very poorly/very well in their individual exam (aggregated mean marks)

other well. In the Finnish case, the teacher assigned the high school students to groups, with the aim to create balanced groups in terms of content knowledge and to ensure that at least one group member had good English language skills to manage the English-based virtual learning environment (see Table 1 for further details).

2.2. Participants

The study involved four groups from each research site ($N^{groups} = 8$; $N^{students} = 28$), who were selected from a larger pool of groups. The main inclusion criterion related to science learning outcomes, selecting two higher-achieving and two lower-achieving groups from each site. In the case of the high school students, quality of achievement was assessed by two independent science professionals on the basis of group PowerPoint presentations of a research project directly related to their collaborative activity. In the case of the teacher education students, groups were selected on the basis of their aggregate mean mark on the science final examination, as collaborative activities did not involve measurable group or individual learning outcomes. The final examination focused on the science content studied in the whole unit, thus comprised the content underpinning the group activities, but also content presented in lectures and the textbook. Additional inclusion criteria were a) that groups remained intact for three lessons on different days (high school students) or for all lab sessions during the introductory course (teacher education students); and b) that the video data were of sufficiently high quality to support meaningful analysis. For authenticity, only the "best possible" option applied in the high school groups, meaning that one member of one group was absent from the final lesson.

Regarding the participants' science background and knowledge, the high school students' science and English language grades, number of science courses taken, and their scores on biology and chemistry tests given prior the studying in the virtual environment were not significantly related to quality of group outcomes. In regard to the teacher education sample, their science content knowledge was not formally tested since enrolment in the introduction to science unit was not permitted for students who had successfully undertaken post-secondary science units prior to enrolment in the teacher education program. The science background of this whole sample was therefore limited.

Participation was voluntary at both sites. Signed consent for video recording of the groups' interactions was provided by the teachers and students (or legal guardians of students under 18 years of age at the high school site). To ensure confidentiality, video material was processed exclusively by members of the research team. All coded data were anonymized using participant pseudonyms, and all material was stored according to regulations in both countries. Ethical principles were rigorously applied in accordance with university and national guidelines.

2.3. Role data and analysis

2.3.1. Role data

The role analysis addressed two task phases from the total activity set: the initial *planning phase* and the *concluding phase* (see Table 1). These are generally recognized as two key phases in science-related collaborative inquiry (see Pedaste et al., 2015). The middle phase (*experimenting*) was not included because the teacher education students completed that part outside the classroom, making it unsuitable for meticulous role analysis.

The video segments selected from the two phases were considered meaningful for role analysis because they captured on-task instances of group engagement; episodes that did not refer directly to the task at hand were excluded from the analysis. However, specific turns *introducing* off-task topics were included to identify actions seeking to derail group from on-task. In total, we analyzed 1 h 50 min of high school video data and 2 h 2 min of teacher education footage. As shown in Table 2, the number of analyzed turns varied across groups, which was expected as the data were collected during authentic activities that were in part student-led.

2.3.2. Role analysis

The analysis involved two steps: 1) *coding of observed discrete functional participatory roles* from the video data and 2) *identification of role profiles* based on the initial coding and subsequent clustering.

2.3.2.1. Coding of observed functional participatory roles

Table 2
Total number of analyzed turns by data set and group.

High school (HS)		Teacher education (TE)	
Group	Turns n	Group	Turns n
HS-Higher A	483	TE-Higher A	370
HS-Higher B	275	TE-Higher B	383
HS-Lower C	507	TE-Lower C	135
HS-Lower D	364	TE-Lower D	298
(totals)	1629		1186

Note. 'Higher' and 'Lower' refer to level of group achievement. The single letters at the end (A–D) are group identifiers.

2.3.2.1.1. Coding scheme. The coding of *task-focused* roles employed an analytical framework developed by Heinimäki et al. (2020), which identifies two types of task-focused functional participatory roles. *Core* roles are those considered intrinsic to collaborative science learning because they commonly emerge in any such setting. *Activity-specific* roles typically vary across settings because they relate more closely to the specifics of a given learning environment, such as materials and tasks. In the present study, as the empirical evidence used to develop the framework and its applied coding schemes was partly based on both of these data sets (Heinimäki et al., 2020), the coding schemes had already been validated, and no further testing was required prior to coding.

Following Volet, Jones et al. (2019), core and activity-specific roles were further assigned to three broader categories: *science content-focused* (including *knowledge provider, knowledge seeker, information giver, information seeker, challenger, supporter*), who base contributions on science or facts, as in scientific explanations; *opinion sharing* (*opinion giver, opinion seeker*), who base contributions on personal views; and *experiment- and process-focused* (high school: *follower, recorder, dictator, technology contributor, navigator, attention focuser;* teacher education: *follower, procedural contributor, reader*), who contribute to the task in mainly procedural ways rather than offering science-related inputs. All of the activity-specific roles identified here fell into this last category. More detailed descriptions and coding indicators for each discrete role can be found in Heinimäki et al. (2020).

The coding scheme in Heinimäki et al. (2020) focused exclusively on task roles and was expanded here to include socio-emotional roles, based on a slight modification of Heinimäki et al.' (2019) earlier scheme as originally developed to capture socio-emotional roles from the same high school setting. Exploratory analysis confirmed that the coding scheme was also suitable for analyzing the teacher education data. The coding scheme took account of both *positive* and *negative* socio-emotional contributions in relation to the goals of the activity (cf., Lehmann-Willenbrock et al., 2016). Given the purpose was to collaborate on a science-learning task, the *harmonizer* role (providing positive feedback and enhancing group atmosphere) is considered positive while the *negativity* role (making negative comments about the task or other members) and the *off-task initiator* role (distracting on-task by introducing off-task topics) are considered negative in this particular scheme, although it is acknowledged that off-task interaction can sometimes be productive for collaboration (see, Langer-Osuna, Gargroetzi, Munson, & Chavez, 2020).

2.3.2.1.2. Coding. It was anticipated that functional participatory roles would emerge during interaction and would fluctuate dynamically among group members. In line with this micro-level conceptualization, coding was performed at *turn level* (Hennessy et al., 2020). Using professional video analysis software The Observer XT (Noldus, 2017), coding targeted mainly verbal contributions, capturing even brief utterances from the group interaction (e.g., "ok"), along with clear non-verbal contributions (e.g., nodding, operating a laptop).

First, the video data was incorporated into the Observer XT and carefully divided into discrete turns as preparation for the role coding. Like in earlier studies by Lehmann-Willenbrock et al. (2016) and Volet et al. (2017), the role coding was then carried out in such a way that only one discrete functional participatory role from the coding scheme was assigned to each turn. Discrete turns were typically brief, thus only one role emerged in most turns. It is only in the case of uncommon longer turns, that we sometimes noted a secondary role. In such cases, we followed Volet et al. (2017) and coded only the dominant functional role in the given turn. One example of this comes from the high school data, when during a longer scientific explanation a student additionally operated the group's laptop for further demonstration, which was coded as dominantly science-based rather than procedural input. Furthermore, in our conservative coding protocol, science content-focused roles were assigned only when the task-related contribution was clearly observed as based on science or facts, thereby unequivocally distinguishing it from mere personal opinion or procedural contribution. In turn, socio-emotional roles were assigned over task-focused roles only in case the main function of the turn was considered harmonizing, negativism, or off-tasking. For instance, saying something with a positive tone (e.g., "Yes, we were totally right!") was not automatically coded as harmonizer-role, but it required stronger indicators derived from the content of what was said (e.g., "Good job, everyone!").

The experiment and process roles were the most commonly enacted types in both data sets (more than 50% in both cases; see Appendix A). However, the high frequency of these procedural roles did not adequately capture the full student profiles (see Section 2.3.2.2). For this reason, classifying and labeling profiles involved integrating an accompanying role that would distinguish meaningfully between them. Most profiles were based on task-related roles while socio-emotional roles were rare, predominating in only two cases.

2.3.2.1.3. Inter-rater reliability. Two researchers performed the coding for each data set (primarily the first and the third authors, who were involved in developing the coding scheme). In parallel, 31.7% of all turns (891/2815) were independently rated. The alternate coder for the Finnish data was an experienced researcher who was also familiar with the coding scheme. Inter-rater reliability for the two coders on each dataset were computed on a turn-by-turn basis, targeting data coded by both and including data from every group. Inter-rater agreement varied from 85% to 95.3% across the groups; Kappa values ranging from 0.80 to 0.89 indicated "substantial" to "almost perfect" inter-rater agreement according to Landis and Koch (1977, p. 165). All disagreements were resolved through discussion between the raters while reviewing the video data together.

2.3.2.2. Role profiles. Based on the turn-level video data coding of discrete functional participatory roles hierarchical cluster analysis was used to identify roles profiles. The aim was to generate a number of unique role profiles among students, as cluster analysis identifies internally uniform clusters that vary significantly from others (Everitt, Landau, Leese, & Stahl, 2012). Cluster analysis is recognized useful in identifying non-obvious patterns in observational data (Lehmann-Willenbrock & Allen, 2018), and it has been successfully used to identify emergent group roles in team meetings (Lehmann-Willenbrock et al., 2016) and during online learning (Dowell et al., 2019).

The implementation of cluster analysis was based largely on Lehmann-Willenbrock et al.'s (2016) protocol and carried out by using SPSS software (IBM SPSS Statistics, version 25). First, the outcome data of the video coding was exported from Observer XT to Microsoft Excel, where the data was prepared for cluster analysis, and then exported to SPSS. In the clustering, we used frequencies of enacted functional participatory roles converted to percentage values to standardize the data across individuals and groups. Rather than discrete roles, aggregated values were used, referring to each of the broader role categories (see Section 2.3.2.1 for coding scheme). This was considered appropriate as the discrete roles within each category were similar in nature and basic function. It also enhanced the robustness of the cluster analysis, as the number of variables was reduced from 17 (high school) and 14 (teacher education) to 5.[1]

Hierarchical cluster analysis was used as a clustering method with Ward's algorithm and Euclidean distance proximity measure because the sample size was relatively small and the likely number of clusters was not presumed in advance (Antonenko, Toy, & Niederhauser, 2012). The analysis was performed independently for both data sets. As there is no reliable statistical means of identifying the optimal number of clusters in small data sets (Lehmann-Willenbrock et al., 2016), the final selection of clusters was determined by careful scrutiny of multiple different solutions. This included examining the within-group consistency of individual clusters, differences between clusters, and the conceptual validity of the clusters in reference to the five role categories (Antonenko et al., 2012).

3. Results

The next section describes the individual role profiles generated by separate cluster analysis of each data set (high school, teacher education) (individual-level analyses, RQ1), followed by the relationship between role profile configurations and group achievement (group-level analyses, RQ2).

3.1. Student role profiles (RQ1)

The cluster solution retained for both high school and teacher education students comprised 5 role profiles. Each profile is briefly described in Table 3, and Appendix A details within-student distribution of roles, highlighting dominant roles. As shown in Table 3, all three *common* profiles (i.e., those emerging in both data sets) were task-focused. Other profiles were *specific* to a particular setting; in each setting, four of the five identified role profiles were task-focused while one had a distinct socio-emotional focus. Task-focused role profiles that differed across the two data sets reflect the unique characteristics of each setting.

Table 3
Common and specific role profiles: high school and teacher education students.

Common profiles	
Opinion focuser	Favored opinion-based contributions during task completion, as indicated by their relatively high focus on opinion sharing.
Content-based performers	Favored science content and experiment- and process-focused roles, indicating a tendency to employ scientific evidence for task completion.
Procedural managers	Contributed mainly to procedural aspects of the task as indicated by high proportion of experiment and process-focused role enactment.
Profiles specific to high school students	
Content-opinion contributors	Participated in task-related interaction at both more and less sophisticated levels (science content and opinion sharing, respectively), making relatively few procedural contributions.
Content-social contributor	One student favored science-based roles when on-task but occasionally shifted to positive (harmonizing) as well as negative (off-task initiation) social roles.
Profiles specific to teacher education students	
Content contributors	Predominantly favored science-based roles, with only minimal adoption of other roles.
Distractor[a]	One student exhibited clear task avoidance, contributing minimally to the group effort and making negative social contributions (off-task initiation).

[a] Labeling of this profile follows Maloney (2007, p. 388), who characterized the Distractor as someone who “talks about issues not related to the task”, and Hogan (1999, pp. 864-865), who reported the “promoter of distractor” as someone who “constantly made light of their tasks through their silly behaviors” and “communicated their unwillingness to take the knowledge-building process seriously”.

[1] Joel, for example, enacted 158 discrete functional participatory roles (in frequencies) over the course of the activity (see Appendix A). Of these, 33 were opinion giver and 19 opinion seeker roles, totaling 52 in the broader opinion sharing role category and amounting about 32,9% of all his roles. The percentage values used in the clustering were calculated alike for all the five broader role categories and each student.

3.2. Student role profile configurations and group achievement (RQ2)

As shown in Fig. 1, each group exhibited a unique configuration of role profiles; as anticipated, the most notable differences were between higher- and lower-achieving groups. Science content-based profiles (i.e., *content-based performer, content-opinion contributor, content-social contributor, content contributor*) were more pronounced in the higher-achieving groups. Interestingly, *opinion focuser* profiles stood out in the lower-achieving groups. The versatile science-oriented configurations identified in higher-achieving groups contrasted with more homogenous role profiles among lower achievers. Only one student in a lower achieving teacher education student group had a clear socio-emotional profile (*distractor*), and its influence on group work is apparent in the illustrations (see Section 3.3).

3.3. Narrative case examples: student role profiles and their relation to achievement

To dig deeper into how student role profiles combined and interacted during group activity, we also conducted a thorough examination of some selected groups by returning to the video data to scrutinize qualitative aspects of group interactions. The selected groups represented higher and lower achievers from each data set (HS-Higher B, HS-Lower A; TE-Higher A, TE-Lower A; see Fig. 1). These are discussed with reference to brief discourse excerpts and individual role profiles.

To begin, we consider two contrasting cases: how a predominantly science content-oriented role profile configuration may have promoted higher achievement (case 1), and how a predominantly opinion-focused configuration may have contributed to lower achievement (case 2). We go on to consider two less straightforward cases: what happens when a group is split between content-focused and opinion-focused role profiles (case 3), and how a single student can distract a group that is otherwise predominantly task-focused (case 4).

3.3.1. Case 1: mixed dominant science content profiles (HS-Higher B)

This high school group featured a predominantly science content-oriented configuration—content-based performer Sofia, content-social contributor Ellen, and content-opinion contributor Paula—all mutually supportive. The qualitative analysis sought to illuminate how the interplay of these content-oriented profiles may have contributed to this group's successful task outcome (their group presentation). In line with this group's science content-based configuration, the qualitative analysis revealed that the group members frequently engaged in shared knowledge building processes. The first excerpt below shows how they co-constructed a more refined understanding of the Baltic Sea's ecosystem, which was crucial for successful planning of their virtual experiment.

> Sofia: What belongs to it? (the ecosystem)
> Ellen: Well, everything that grows.
> Paula: I don't know what else besides a lot of algae.
> Sofia: Why is pH important? (looking at the others)
> Ellen: Well, it affects what can live there, right?
> Sofia: Yeah, and that's probably why some planktons and other [organisms] can't survive…
> Paula: And [it probably affects] the growth of some plants too.
> Ellen: Yes! (in an encouraging tone)
> Paula: Great, I knew a lot! (joking, meaning the opposite)

This excerpt illustrates how this group gradually built a deeper content understanding, not only by sharing pre-existing knowledge but also by collaboratively building on fragments of information, and sometimes even from lower-level contributions such as opinions. Importantly, the students had the confidence to contribute, regardless of their (stated) knowledge gaps and uncertainties (like Paula in the above excerpt). The genuine attempts to engage with the task even at scientifically lower levels enhanced the co-construction process, as they often elicited further explanations and questions from others that brought the group closer to new understandings and solutions. The affordances of building successfully on lower-level contributions is visible in the next excerpt, where Sofia repeatedly challenged others' viewpoints in order to arrive at more science-based solutions as a group.

> Sofia: Why…? (wonders about something irrelevant happening on the computer)
> Ellen: Don't bother, let's just get on with the task. (joking, laughing)
> Ellen: So, what happens to the eggs?
> Paula: Well, of course, it relates to the pH. (laughs as is misspelling "pH" at first try)
> Ellen: pH can indeed have an effect on the eggs.
> Sofia: (using the computer) But we have to say how it affects them.
> Paula: Their development, somehow…
> Sofia: But we have to say, like, its effects if it is acid or alkaline, We can't simply state that "It affects"!

This group's predominantly science content-focused profiles manifested as rich task-related interactions that promoted shared knowledge building and productive task completion, and was evident in their group presentation. The other accompanying roles (procedural, opinion, socio-emotional) were seen to support rather than interfere with these processes, as the affordances they provided for deeper understanding and successful task completion were productively harnessed by the group. The next case illustrates the opposite situation, when the configuration of role profiles is predominantly opinion-focused.

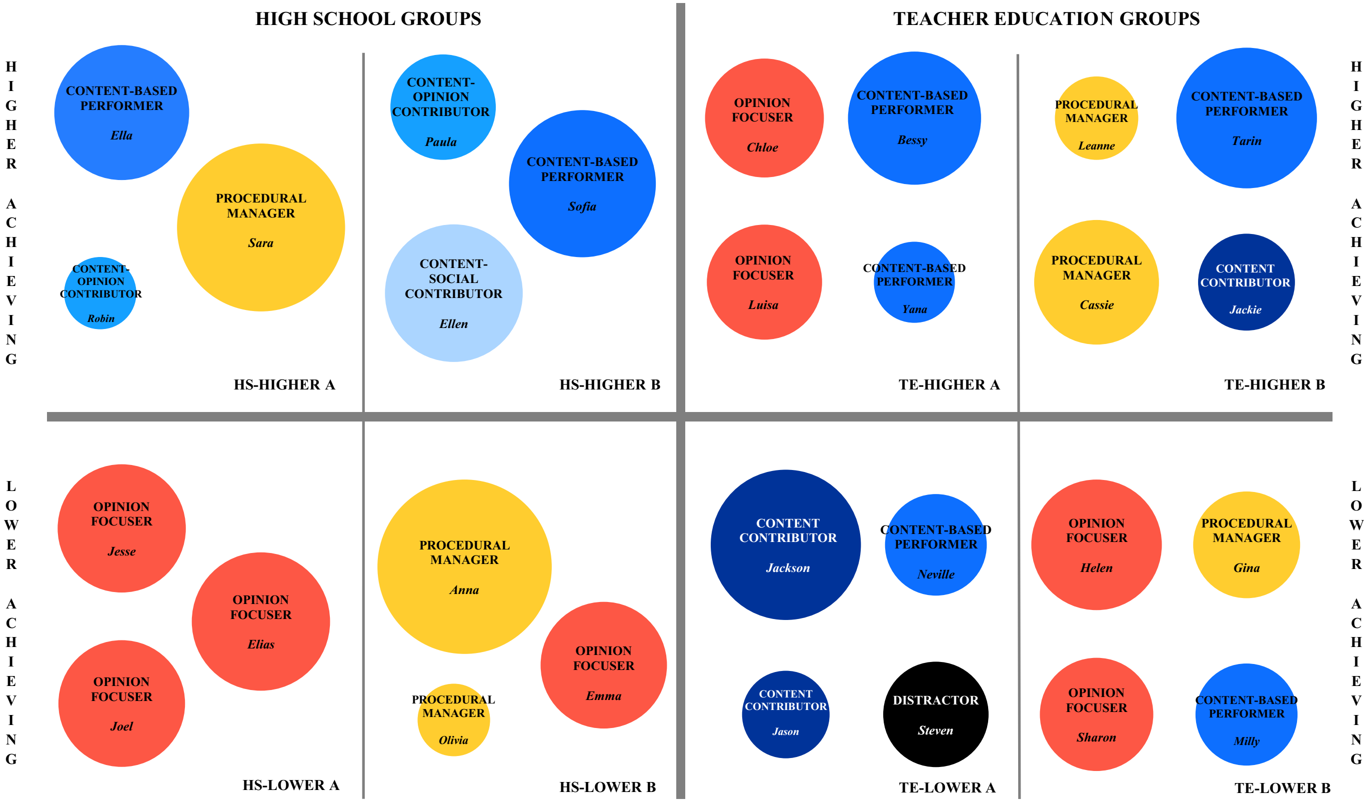

Fig. 1. Role profile configurations in the higher- and lower-achieving groups.
Note. Circle size represents frequency of functional participatory roles enacted by students during the activity relative to the role frequencies of other group members, illustrating how contributions were distributed within each group (see, Appendix A).

3.3.2. Case 2: opinion-dominant role profiles (HS-Lower A)

All of this group's members (Jesse, Elias, and Joel) displayed an opinion focuser role profile, representing an extremely opinion-dominant configuration that can be assumed to relate to the group's lower achievement. The aim of the qualitative analysis was to shed further light on this relationship. It became clear that this opinion-focused profile started to develop from the very beginning of the planning phase. Specifically, the group struggled to generate a hypothesis for their upcoming experiment, and their discourse as they tried to figure it out remained low-level in terms of science. The first excerpt illustrates how Elias eventually tried to elevate the discussion from opinion-based to something more science-based in order to link their hypothesis to actual scientific evidence, but his attempt was neither supported nor sustained by the other group members.

Jesse: It's quite nice that the number of eggs produced increases.
Elias: But does that happen? What does pH do to these creatures? Does it have an effect?
Elias: (continues after a while as nobody is responding) Although this is a hypothesis, I don't feel like putting in something totally fictional! (laughs)
Jesse: Yeah! (laughs)
(Everyone looks silently at the laptop screen for some time.)
Jesse: What is this? (touches the keyboard; group moves into off-task mode)

Soon after, Joel attempted twice to re-orient the discussion back to the hypothesis formation, but these attempts were unsuccessful. Finally, Joel ended up proposing his own idea, but even that did not elicit any further discussion or actions on the matter.

Joel: Basically, if some of those increases (leans forward and points the screen with a finger), they all increase.
Elias: Yeah.
Joel: Should we then just write simply like that to every section?
Jesse: It is fine with me. (everyone are silent awhile, until Joel and Elias starts discussing about something else)

These elevation attempts became rarer as the activity proceeded, and discourse became increasingly opinion-based. These low-level opinion-based contributions sometimes seemed to indicate a desire to just get the task done without deeper scientific reflection, which is illustrated in the next exchange between Elias and Joel as a response to Jesse's attempt to understand better the phenomena in their hypothesis formulation.

Jesse: Was some reason provided for it [in the virtual environment]? (starts exploring the virtual environment)
Elias: There are no reasons for it—this is science! (sarcasm)
Jesse: We still have to investigate it.
Joel: Let's just guess.

Overall, this group's opinion-dominant configuration was clearly reflected in the content of their discourse, which remained largely low level, both cognitively and scientifically, and may have contributed to the lower quality of their final presentation. When occasional attempts were made to introduce more science-based discourse, the attempts remained singular as the rest of the group failed to build on these opportunities, which was a stark contrast to the rich and reciprocal interplay of roles evidenced in the first case illustration (see Case 1, 3.3.1). The next case illustrates what can happen when science-based and opinion-based role profiles are equally represented within a group.

3.3.3. Case Illustration 3: 'split' science and opinion profiles (TE-Higher A)

This group represents an interesting 'split' between science- and opinion-based roles; while Bessy and Yana displayed content-based performer profiles, Chloe and Luisa were opinion-focused. The qualitative analysis therefore sought to develop a fine-grained understanding of how the dynamic interplay of these profiles succeeded in building on simple, opinion-based comments, incorporating them into science-grounded discussion. From early in the task, Chloe and Luisa more often contributed in "lay" terms, which were occasionally reframed by Bessy and Yana in relation to the process of science experimentation that was a key learning goal of the lab, as illustrated in the three brief excerpts below. In the first, the group discussed what to measure in their 'rocket', which Yana linked conceptually by verbalizing that this was their *independent variable*, which they then all documented.

Chloe: It means if we put more or less then, how long's-?
Bessy: It effects the speed; which it will, yep.
Yana: So, the independent variable is how much. Amount of bicarb.

A few minutes later the group is forming their hypothesis, which Bessy urges the group to underpin scientifically.

Chloe: Yeah, I am just gonna say that…the more bicarb, the faster it will react…
Bessy: Why is that? What's the science behind it? Because? (looking around the group before offering a suggestion)

In the third example, the group considers 'factors that could affect the investigation'. Luisa suggests temperature, adding that she does not know. Bessy takes up the notion of temperature to consider the effect of heat.

Luisa: The temperature of the vinegar; I have no idea.
Yana: We could vary the temperature of the vinegar.
Bessy: So, if you used hot vinegar, would that make it explode much quicker?
Luisa: That would be really cool to do.
Yana: But we can only change one thing (referencing the independent variable).

The above examples are evidence that the group took up opportunities that arose to build on lower-level contributions by reframing them more scientifically. For instance, one of the key learning objectives of this lab was that these low science background students could learn the important role of the *independent variable* (and control variables, etc.) in the scientific experimentation process. Hence, Yana's linkage of their household experimental material (bicarb soda) as their independent variable, and later noting that they could only change one thing, were important for the group's understanding of the experimentation process in their experiment planning. In this way, opinion roles were elevated by science content roles and thus linkage of lay terms with the science concepts that the students needed to learn not only in order to understand what they were doing in the lab in scientific terms but also since the students would need to use, and demonstrate their understanding of the correct science concepts and terminology in the end of semester exam. The final case illustrates the impact on the entire group of one group member's distracting actions and how these can derail other members' efforts to develop and sustain their focus on the science task.

3.3.4. Case 4: one distracting profile within science content profiles (TE-Lower A)

In this group, Jackson and Jason were content contributors, Neville was a content-based performer, and Steven was identified as a distractor. The key question here was how a majority of content-focused members were not able to build on this potential affordance for a collective science-focused task effort. Although three members' role contributions reflect their willingness to engage with the science task at hand, Steven consistently pursued off-task talk—first with Jason, who was seated nearest to him; then with Neville using eye contact and joking, and finally with Jackson, who appeared resolutely science-focused. As the group work commenced, Steven started off-task joking in side-chat to Jason, then drew Neville into the bantering. A few minutes later, as Jackson and Jason discussed what to measure and observe, Steven again disrupted the science focus by directly targeting Jackson at a personal level.

> Jackson: … so the control variable would be like the amount of bicarbonate soda, and then we could change the amount of vinegar we are putting in—does that makes sense? (continues discussing, providing a concrete example)
> Jason: So, what's our independent variable?
> Jackson: I'm just trying to talk it out with you. I don't know. I'm just trying to get someone else's opinion (sounding mildly exasperated as he struggles to elicit input and maintain group focus).
> Jason: Okay.
> Steven: Will we call him [nickname]? (suggests a famous actor's name, disrupting the science talk immediately after Jackson's appeal for group input)

Up to this point, Jackson was task-focused, prompting group science discussion. However, whenever Neville and Jason engaged in science talk with Jackson, Steven intervened by joking, eventually encouraging the group to move off-task as they all joked about the actor in question. These unfolding role contributions confirm that three group members set out with the task goal in view. For example, when Steven bantered, Jason sometimes looked down, turning pages in his lab book, and he and Neville glanced toward Jackson in a subtle attempt to return to the task. However, Steven's goal was clearly divergent, explicitly social, and task avoidant. The off-task banter he initiated evolved throughout the session, distracting the entire group from their task. When the group did return on-task, Jackson resumed his efforts to get the others to focus on the science at hand. The extent to which Steven's distracting behavior was repeated throughout the semester and inhibited his peers' learning from the group activities would need to be established in a rigorous way but there were informal indicators that it was the case.

4. Discussion

This study investigated self-adopted functional participatory roles and role profiles in two authentic collaborative science learning settings. The study first explored student role profiles during collaborative learning and then investigated how different within-group role profile configurations related to science achievement. The study contributes conceptually, methodologically, and empirically to the sparse literature in this area: 1) Building on Strijbos and De Laat's (2010) notion of micro- and meso-level roles, the conceptualization of role profiles was refined to include emergent micro-level patterns of discrete functional participatory roles; 2) on that basis, different levels of analysis were performed to identify student role profiles, using fine-grained observation of functional participatory roles at the micro-level to inform statistically driven identification of role profiles at the meso-level; and 3) exploration of student role profile configurations in higher- and lower-achieving groups facilitated in-depth investigation of how role profiles dynamically combined during the group task and how different role profile configurations relate to actual scientific achievement.

4.1. From student role profiles to within-group role configurations: Relation to achievement

4.1.1. Student role profiles

Seven role profiles were identified, three of which were found in both learning settings while four were detected in only one setting. This finding aligns with Heinimäki et al's. (2020) claim that some roles can be characterized as *core* because they can be expected to emerge in almost any science learning setting while other activity-specific roles are unique to a certain collaborative science learning setting or activity. All of the core role profiles (opinion focuser, content-based performer, procedural manager) were task-focused but differed in terms of contribution and engagement with the group task.

Of these, the most common was the *opinion focuser* (superficial opinion-based orientation to task content). This profile bears some resemblance to Hogan's (1999) “promoter of simple task completion”. However, as opinions sometimes emerged as genuine attempts to engage with the task, the presence of opinion focusers in both learning settings may also reflect the disparity between students' skills and the challenging task demands, inhibiting enactment of more science- and knowledge-based roles. Of all the identified profiles, *procedural managers* displayed the most systematic focus on task performance. Previous research has identified group members whose main focus was on "doing things for the group" (e.g., the "procedural technician" in Benne & Sheats, 2007, p. 32). The procedural manager identified here also fits this description. Given the importance of procedure in almost any group setting, some students may adopt this role because it seems meaningful while avoiding more cognitively demanding input. Interestingly, the *content-based performer* was the only profile to encompass both "thinking" (i.e., science content) and "doing" (i.e., experiment and process) roles. The fact that content-based performers were much more common in higher-achieving groups suggests that the inherent flexibility of this profile may have had a positive influence on productive collaboration. This conclusion is consistent with existing evidence of the valuable role played by group members who can respond flexibly to situational demands (Benne & Sheats, 1948, 2007; Forsyth, 2014; Volet et al., 2017).

Two role profiles specific to a single setting were identified as task-focused (high school: content-opinion contributor; teacher education: content contributor), and two profiles exhibited a distinct socio-emotional focus (high school: content-social contributor; teacher education: distractor). These profiles reflect the unique characteristics of the two learning settings in terms of activities, tools, materials, and (probably) student background. Interestingly, the *content-opinion contributor* was simultaneously science content- and opinion-focused. This suggests that these students may have found the group atmosphere encouraging and psychologically safe (see Newman, Donohue, & Eva, 2017), giving them the necessary confidence to move between an opinion-based role and a more demanding science-based role despite their observed uncertainty.

While the *content-social contributor* profile contributed in mainly positive ways to task and atmosphere, the *distractor's* contribution was almost entirely negative. The distractor role has also been identified in other studies (Hogan, 1999; Maloney, 2007), indicating that this profile is likely to be found in many settings and groups. The absence of negative profiles among the high-school students may relate to their academic circumstances; while all of the high school students had themselves chosen advanced science courses in question, the teacher education students were participating in a mandatory introductory science course designed to enrich their scientific interest and knowledge.

4.1.2. Within-group role profile configurations and achievement

Higher- and lower-achieving groups clearly differed in terms of role profile configurations. While science content-oriented role profiles were typical of higher-achieving groups, opinion-based profiles prevailed in the lower-achieving groups, along with one distractor profile. These findings are consistent with prior evidence of a positive relationship between collaborative learning outcomes and groups displaying positive high-cognition roles (e.g., Hogan, 1999; Maloney, 2007; Oliveira et al., 2014; Volet et al., 2017). The present study, however, extends to this evidence by revealing unique role profile configurations, and illustrating further the dynamic interplay of role profiles in different higher- and lower-achieving groups. Successful knowledge co-construction is known one of the key elements in productive collaborative learning (Cress & Kimmerle, 2018; King, 2002), and the qualitative analysis revealed how science content-oriented role profiles principally found in the higher achieving groups played a significant part in productive co-construction, such as in attending meaningfully to other member's contributions and elevating the discussion to more science-based. Furthermore, the finding that versatile science-oriented role profile configurations are more prevalent in higher-achieving groups is consistent with Belbin's idea of "role balance" (e.g., Belbin, 2010), which posits that groups with a diverse mix of roles can outperform less balanced groups in which certain roles are over- or under-represented (Meslec & Curşeu, 2015; Prichard & Stanton, 1999).

The present findings also contribute to the broader discourse around the optimal design and structuring of socially shared learning activities to promote high-quality collaborative learning outcomes. In line with Stempfle et al. (2001), the higher-achieving groups in the present study were able to spontaneously adopt role profiles that combined successfully. Somewhat unexpectedly, however, some high-achieving groups were not predominantly science-oriented. This finding aligns with research based on the work of Vygotsky (1978), highlighting the benefits of grouping students of varying ability in collaborative learning settings (O'Donnell & Hmelo-Silver, 2013; Webb, 2008). For instance, our findings suggests that opinion roles are not inevitably detrimental for productive collaborative learning, but can actually be useful when meaningfully supported by science-content roles. In such diverse groups, opinions can lead to rich learning interactions as they have the potential to elicit further questions, explanations, and justifications from peers, which, in turn, can contribute positively on achievement as documented in previous research (Hooper & Hannafin, 1988; Weinberger, Stegmann, & Fischer, 2007). The less functional and diverse role profile configurations typically seen in lower-achieving groups serve as a reminder of the potential pitfalls of collaborative learning led fully or partly by students (Kirschner, Sweller, & Clark, 2006; Kreijins, Kirschner, & Jochems, 2003). This confirms the importance of teacher guidance, especially for students who lack the necessary discipline and social skills for high-quality collaboration and co-construction (Hmelo-Silver, Duncan, & Chinn, 2007; Lehtinen, Lehesvuori, & Viiri, 2019). A further important issue arising here is group vulnerability to the influence of even one dysfunctional member. Although this has been addressed in other fields like organizational sciences (e.g., Felps, Mitchell, & Byington, 2006), it remains neglected in the collaborative learning literature and should be urgently addressed in future research.

4.2. From micro to meso: methodological contributions

As mentioned earlier, the present study's methodological and analytical approach takes account of the multilevel nature of functional participatory roles in social learning contexts (Strijbos & De Laat, 2010). By grounding the identification of role profiles (the meso level) in moment-to-moment observation of functional participatory roles as enacted by students (the micro level), we developed a rigorous statistically driven analysis of patterns and clusters of discrete functional participatory roles as individual role profiles.

Although some previous studies also identified role profiles on the basis of observed student behaviors (e.g., Hogan, 1999; Maloney, 2007; Richmond & Striley, 1996), the observations were typically less detailed and could not fully capture the spontaneous and dynamic nature of participatory roles and role profiles. The empirical evidence presented here responds to recent calls (Lehmann-Willenbrock et al., 2016; Oliveira et al., 2014; Volet et al., 2017) for research that both conceptualizes and captures the highly emergent, interactive, and dynamic nature of roles and role profiles. Furthermore, as most prior empirical research on roles has been carried out as single studies, with each study having unique methodology and conceptualizations (Heinimäki et al., 2020; Strijbos & De Laat, 2010), our approach to study participatory roles systematically with the same methodology in two different settings has important value in advancing research of roles in collaborative learning.

The use of cluster analysis to identify student role profiles from observational data was inspired by earlier studies by Lehmann-Willenbrock et al. (2016) and Dowell et al. (2019). However, as these studies were conducted in a different context (team meetings and online learning), we believe the present study is the first to apply this method to face-to-face collaborative learning. Interestingly, however, Maloney (2007) explicitly mentioned that "'clusters' of similar actions" were used to "build a picture of the roles children played" during collaborative science learning in a face-to-face setting (pp. 385–386). However, it remains somewhat unclear how those roles were actually generated, as the amount of observed actions was not reported and the clusters were manually rather than statistically build. It is expected, therefore, that the data-driven approach in the present study basing the identification of role profiles to countable contributions (frequencies derived from detailed video data coding) and subsequent cluster analysis will provide more objective and transparent approach to future explorations of roles.

4.3. Limitations and future research

Although the present analysis of role profiles was based on rigorous procedures, the study also has some limitations. First, the role profiles related to students' activities during selected task phases, and other role profiles may have been identified if all of the video data had been included in the analysis. Specifically, as the selected segments focused mainly on on-task situations and only the first turn of longer off-task episodes was included, socio-emotional role profiles might be expected to figure more prominently. Although in the present study we found evidence of the negative function of the discrete off-task initiator role as distracting the group from working on the task, it should be noted that off-task interactions are by no means always negative, but can also have many useful functions in collaborative learning, for instance by offering alternative ways for individual participation and sustaining collaboration (Langer-Osuna et al., 2020). This points for the need of deeper, more systematic research on the interplay of on-task and off-task interaction in productive collaborative learning. Secondly, as explained in Section 2.3.2.2, the broader role categories used as aggregates in the cluster analysis invite further research to explore the possible emergence of more nuanced role profiles in larger data sets that would support a more itemized approach.

While this study is based on two distinct data sets in ecologically valid settings, more research is needed in other settings and with larger data sets to support any generalization of these findings. Furthermore, a noteworthy limitation concerning the teacher education sample relates to the outcome measure used to distinguish between higher- and lower-achieving groups. Unlike in the high school context, where the quality of achievement was assessed on the basis of a tangible group product (presentation) directly linked to the collaborative activity, only a non-direct outcome measure (aggregated individual final exam marks) could be used in the teacher education context (see, Section 2.2). This implies caution in interpretation, since there could be other factors outside the collaborative activity that could have influenced on the achievement. In future research, the relationship between role profile configurations and achievement should be therefore also explored in more controlled settings to allow more causal interpretations.

More research should be also devoted to understanding how individuals' background may influence to role profiles they exhibit during collaborative learning, which would provide important supplementary lens to observational research. Research at this macro-level (see, Strijbos & De Laat, 2010) could explore, for instance, any relationship between students' role profiles and their prior knowledge (Biddle, 1979), attitudes (Volet, Jones et al., 2019), personality traits (Stewart et al., 2005), or cultural background (Gu, Wang, & Mason, 2017). Furthermore, it would be interesting to follow students' role profile trajectories over time to assess their consistency; for instance, do students aspire to more favorable profiles as they become more knowledgeable and/or motivated in terms of disciplinary content?

4.4. Practical implications and concluding remarks

This study expands our understanding of how role profile configurations relate to achievement in socially-shared science learning and contributes conceptually and methodologically to research on emerging role profiles. The findings have practical implications for teachers in "bridging the gap between low and high achievers" in social learning contexts (Dobber, Zwart, Tanis, & van Oers, 2017, p. 194). As preparation for collaborative learning, it would be useful if teachers could model productive role profiles to encourage flexible adoption by students, and to scaffold the collaborative efforts of lower achievers. Teachers could also provide detailed information about the characteristics, functions and impact of different role profiles, the aim being to enhance students' awareness and understanding of roles, and to help them adopt those identified as productive and avoid those found counter-productive. The case examples presented here concretize the dynamic interplay of roles and may help to enhance teachers' sensitivity to situations in which groups would benefit from stronger scaffolding and guidance.

In conclusion, the present study highlights the strikingly different role profiles of group members and suggests how different role profile configurations relate to contrasting achievements. The findings confirm the significance of emergent participatory roles in productive collaborative learning and the need for further focused research.

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Appendix A. Student role profiles and distribution of enacted functional participatory roles (by frequencies and %)

Individuals by profiles	Focus										Total
	Task						Socio-emotional				
	Science content		Opinion sharing		Experiment & process		Positive		Negative		
High school											
Opinion focuser											
Joel	33	20.9%	52	**32.9%**	68	43.0%	3	1.9%	2	1.3%	*158*
Emma	30	26.5%	29	**25.7%**	53	46.9%	1	0.9%	–	0.0%	*113*
Jesse	29	18.0%	41	**25.5%**	82	50.9%	4	2.5%	5	3.1%	*161*
Elias	42	22.3%	43	**22.9%**	99	52.7%	1	0.5%	3	1.6%	*188*
Content-based performer											
Sofia	38	**33.0%**	11	9.6%	64	**55.7%**	2	1.7%	–	0.0%	*115*
Ella	54	**31.8%**	21	12.4%	85	**50.0%**	8	4.7%	2	1.2%	*170*
Procedural manager											
Sara	35	13.3%	28	10.6%	184	**69.7%**	13	4.9%	4	1.5%	*264*
Olivia	7	18.9%	7	18.9%	22	**59.5%**	0	0.0%	1	2.7%	*37*
Anna	33	15.4%	52	24.3%	123	**57.5%**	4	1.9%	2	0.9%	*214*
Content-opinion contributor											
Robin	18	**36.7%**	15	**30.6%**	15	30.6%	–	0.0%	1	2.0%	*49*
Paula	21	**35.6%**	14	**23.7%**	17	28.8%	6	10.2%	1	1.7%	*59*
Content-social contributor											
Ellen	34	**33.7%**	8	7.9%	38	37.6%	12	**11.9%**	9	**8.9%**	*101*
Totals	*374*	*23.0%*	*321*	*19.7%*	*850*	*52.2%*	*54*	*3.3%*	*30*	*1.8%*	*1629*
Teacher education											
Opinion focuser											
Sharon	8	10.8%	21	**28.4%**	42	56.8%	–	0.0%	3	4.1%	*74*
Chloe	24	23.8%	27	**26.7%**	45	44.6%	3	3.0%	2	2.0%	*101*
Gina	24	24.5%	24	**24.5%**	48	49.0%	1	1.0%	1	1.0%	*98*
Luisa	18	18.9%	23	**24.2%**	45	47.4%	5	5.3%	4	4.2%	*95*
Content-based performer											
Neville	8	**29.6%**	3	11.1%	15	**55.6%**	–	0.0%	1	3.7%	*27*
Bessy	35	**27.6%**	20	15.7%	65	**51.2%**	1	0.8%	6	4.7%	*127*
Tarin	35	**24.1%**	18	12.4%	88	**60.7%**	1	0.7%	3	2.1%	*145*
Yana	11	**23.4%**	8	17.0%	27	**57.4%**	1	2.1%	–	0.0%	*47*
Milly	12	**20.0%**	13	21.7%	35	**58.3%**	–	0.0%	–	0.0%	*60*
Procedural manager											
Helen	11	16.7%	5	7.6%	50	**75.8%**	–	0.0%	–	0.0%	*66*
Leanne	6	12.0%	5	10.0%	37	**74.0%**	1	2.0%	1	2.0%	*50*
Cassie	19	16.7%	16	14.0%	78	**68.4%**	–	0.0%	1	0.9%	*114*
Content contributor											
Jackson	23	**39.0%**	11	18.6%	22	37.3%	–	0.0%	3	5.1%	*59*
Jackie	27	**36.5%**	9	12.2%	33	44.6%	–	0.0%	5	6.8%	*74*
Jason	6	**30.0%**	2	10.0%	8	40.0%	–	0.0%	4	20.0%	*20*
Distractor											
Steven	1	3.4%	4	13.8%	9	31.0%	1	3.4%	14	**48.3%**	*29*
Totals	*268*	*22.6%*	*209*	*17.6%*	*647*	*54.6%*	*14*	*1.2%*	*48*	*4.0%*	*1186*

For each profile, values that stand out in comparison to other profiles are bolded.
The table shows rounded percentage values. The accurate values were used when the identification of role profiles was undertaken via hierarchical cluster analysis (see Section 2.3.2.2).
Robin was absent from the last phase of the activity (concluding), so his values represent only the first phase (planning).

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