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CLASSROOM SPACE AND STUDENT POSITIONS IN PEER SOCIAL NETWORKS: AN EXPLORATORY STUDY

TOMÁŠ LINTNER,
ZUZANA ŠALAMOUNOVÁ

Abstract

The aim of this explorative research study was to identify the relationship between the positions of individual students in their peer social networks and their classroom seating arrangement through sociometry and social network analysis. We examined the social networks of 17 classrooms comprising 363 students (183 boys, 180 girls) attending lower secondary schools (ISCED 2A). We found that positions in social networks could not be connected with single specific seating positions. Nonetheless, certain tendencies can be observed. Students who are perceived as more likeable sit in the middle column of the classroom and are seated close to each other. Locations inhabited by dominant students are positioned further from teachers and further apart from each other. The increase of the values of degree centrality, closeness centrality, and eigenvector centrality is noticeable in desks positioned further away from the teacher. By comparing these results with studies examining seating arrangements as a means of distributing learning opportunities through student participation, specific zones can be observed in the classroom that could benefit the children seated there in their roles as students and at the same time in their roles as classmates.

Keywords

likeability, dominance, centralities, classroom seating arrangement, social network analysis, sociometry

Introduction and theoretical background

Observations that the space in which education takes place influences the educational processes within it are nothing new. Kohl pointed out in 1971 that such space represents specific values and sends specific messages to all those it encompasses. For example, the notion that there is a "front of the class" or that the teacher's desk is typically taller than those of students (and has a drawer, which the desks of students do not have, etc.), indicates the existence of "the authoritarian mode of delivering knowledge received from above to students who (…) are below" (p. 107). Meighan (1981) called this ability of space to influence a "hidden curriculum of educational buildings" that is learned by students in addition to the official curriculum. Therefore, the problematic relationships between spaces for education and the processes taking place in such spaces have deservedly become the focus of several empirical studies.

Among such studies, those which narrow their focus onto classrooms are the most dominant ones.[1] In these studies, seating arrangement has been recognized as a significant attribute of the classroom space.[2] The term "seating arrangement" refers to specific maps of classrooms that depict the organization of the physical space of a classroom through the positioning of the school desks of students and teacher(s) during education. Numerous studies have examined the relationship between particular seating locations and various factors associated with educational processes in the classroom. There is empirical evidence that students seated in specific seating locations daydream less during classes (Breed & Colaiuta, 1974; Lindquist & McLean, 2011), attain higher academic achievement (Benedict & Hoag, 2004; Perkins & Wieman, 2005; etc.), have different attitudes to education (Getie, 2020), or are absent less often (Burda & Brooks, 1996; Stires, 1980; Zomorodian et al., 2012). Furthermore, studies have indicated that seating location is related to student participation in classroom discourse. It has been established that classrooms contain a so-called "T-zone" or zone of dominant activity. This zone covers the seats at the front of the classroom, in the first desks of all three columns, and the remaining desks of the middle column. According to Bradová (2011,

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1 There are interesting studies focused on the environment of educational buildings; see, for example, López-Chao et al. (2020). Such studies are thematically beyond the scope of this article.

2 Classroom seating arrangement is synonymous with classroom seating order. In this study, we systematically use the first term.

2020), the participation of students is weaker in the last desk of the middle column, so the last desk is not considered a part of the T-zone. Increased communicative activity associated with T-zones has been confirmed by a number of studies (Bradová, 2020; Jones, 1990, Marx et al.,1999), and is closely associated with the distribution of opportunities that students have to learn (Resnick et al., 2017; Sedova et al., 2019).[3] Hence, current research supports the existence of a zone in every classroom in which students participate and pay attention more, daydream and are absent less, and have higher academic achievement, and that this zone is located in the center and front of the classroom.

All these studies raise the question of whether their findings are truly caused by the physical space (a position known as the environmental hypothesis) or whether students themselves choose certain seats in the arrangement that are aligned with their personal characteristics and preferences, a position known as the self-selection hypothesis (see, for example, the experimental study by Stire, 1980). The question has not yet been conclusively answered. Should the environmental theory hold, it would mean that teachers could use seating arrangement as a tool to adjust the learning conditions of individual students. Startling consequences were presented in a study of a secondary school in China by Zhang (2019), who demonstrated how teachers can transform seating arrangements into a symbolic hierarchy and use it as a tool for student stratification, as more successful students are located in more prestigious positions in the classroom.

All these studies perceive the classroom as a space designated for education. Nevertheless, the children and youth who are the focus of these studies perceive the classroom primarily as a social space. Since they spend several hours a day in the classroom with their classmates, a key concern for them—which can be superior to concerns that they associate with education—is having good relationships with others (Adler & Adler, 2003; Cothran & Ennis, 1997; Moscovici, 2002; Šalamounová & Navrátilová, 2021). Far less is known about the way in which seating arrangements may be associated with the positions of individual students in their peer social networks.

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[3] Given that the most prevalent seating arrangement in classrooms is that of students seated in rows and facing the teacher, most studies examining the relationship between communication and the location in the classroom focus on the participation of students in these conventionally organized classrooms. Nevertheless, various types of classroom organization are used in practice, such as groups or modules, circle or half-circle arrangements, U shaped seating, and the "open-plan" classroom (Gremmen et al., 2018; Wannarka & Ruhl, 2008).

The relationship between students' seating locations and their positions among their peers was examined by Babad and Ezer (1993) in a study based on a sample of 2,039 fifth graders from 39 Israeli schools and using the sociometric nomination method. The authors postulated that leaders (students who were identified as leaders of boys or girls by their classmates) were more likely to be seated in the back of the classroom. Granström (1996) found that students seated in the back of the classroom tended to interact more frequently with their classmates seated in the back as well. Van den Berg and Cillessen (2015) chose a different approach by focusing on the interpersonal distance between students and their sociometric popularity and likeability. Using data gathered from 336 children distributed through 14 fifth-grade and sixth-grade classrooms from 11 different elementary schools, the authors found that children who were less liked by others sat towards the edges of the classroom at the beginning of the year; children who sat closer to the center were more liked. On the dyadic level, seating arrangement was associated with likeability as well as with popularity, since children who sat closer to each other liked each other more and perceived each other as more likeable, in accordance with the theory of mere exposure. In their second study, van den Berg and Cillessen (2015) asked 158 fifth graders and sixth graders from 6 classrooms in 4 elementary schools in the Netherlands to create their own seating arrangement together. Having analyzed these student-made arrangements, the authors found that if children liked a specific classmate or perceived the classmate as popular, they placed that classmate closer to themselves in their own preferred seating arrangements.

The present study

In this study, we perceive classrooms as firmly organized social spaces and examine the relationship between classroom seating arrangement and the position of individual students in their peer social networks. Studies examining the relationship between the spatial positioning of students and the position of individuals among their classmates in the classroom have been rare (e.g., Babad & Ezer, 1993, who focused on student leadership; van den Berg & Cillessen, 2015, who studied peer status of individuals represented by popularity and likeability). These two studies applied different research designs. The Babad and Ezer study (1993) was based on the sociometric nomination of highly likeable students; the van den Berg & Cillessen (2015) study focused on interpersonal distance between students instead of on their seating location. To our knowledge, no study has yet examined the association between classroom seating arrangement and the position of individuals in the whole peer social network of classmates.

For this study, we measured the position of individual students within their peer social networks through the common sociometric measures of likeability and dominance; we also included the four most commonly used centrality measures based on social network analysis: degree, betweenness, closeness, and eigenvector. Centrality measures are algorithms that assign scores to individual students based on their prominence within the network structure composed of all their peers and their relationships in the classroom (Wasserman & Faust, 2019). Compared to purely sociometric measures, which assign students scores based on aggregate ratings from their peers, centrality measures account for the relational nature of social positions and assess each student's importance based on their relative position in the whole ecosystem of relations in classroom.

Therefore, the overall aim of this study is to investigate the relationship between student seating position and the student's position within the peer social network by asking the following research questions:

- *What is the relationship between a student's seating position and their likeability?*
- *What is the relationship between a student's seating position and their dominance?*
- *What is the relationship between a student's seating position and their degree centrality?*
- *What is the relationship between a student's seating position and their betweenness centrality?*
- *What is the relationship between a student's seating position and their closeness centrality?*
- *What is the relationship between a student's seating position and their eigenvector centrality?*

We believe that answering our research questions will contribute to the current understanding of the relationship between the space in a classroom and the social processes within the classroom. As Stires (1980) mentioned in his experimental study, classrooms offer only a limited number of seating spaces (and hence a limited number of seating choices) which is why certain students are given specific seating locations that they have not chosen and that are disadvantageous for them. Hence, knowing whether there are positions or zones within classrooms that are associated with certain positions of students within their social networks enables us to work with the educational space.

This direction of research is also aligned with the research inquiry of this special issue, since we do not focus on individual actors and their independent actions related to learning and teaching processes. Instead, our aim is to examine educational actors in their social networks (White, 1992).

Methods

Sample

This study is part of a larger project on educational communication and student academic achievement. The participants of the whole research project were ninth-grade students (aged between 14 and 15 years) from 21 schools located in three different regions of the Czech Republic randomly selected from a representative sample of 163 schools involved in a national survey organized by the Czech School Inspectorate[4] to monitor student reading literacy.

For the current study, some classes were also excluded since education took place in specialized classrooms with unique seating arrangements. Four classes were excluded since students in the classes could change their seating position during their lessons, which they did, and thus their seating arrangement was not stable. In total, we observed 17 classrooms comprising 363 students (183 boys, 180 girls). The mean number of students in one classroom was 20.2 (the smallest classes comprised 15 and the largest 26 students, median = 20.5).

Procedure

Data collection for this study took place in December 2017. Students were given standardized sociometric questionnaires. Instructions were relayed aloud in the classroom and team members demonstrated to the students how to answer questions (using the example of fictional students; no real student names were used). No time limit was given; therefore, students were able to use all the time they needed to complete the questionnaires. They rarely needed more than 20 minutes.

The seating plans of the students in the observed classes were provided by their teachers or were accessible in the classrooms where members of the research team could make copies of them. For this study, we worked with the values provided for each student by their peers in a sociometric rating questionnaire and with that particular student's seating position in the classroom.

In all the researched classrooms, the school leaders and the teachers involved actively consented to participation. The parents or guardians of the children received a letter explaining the research and its aims. They could tell the researchers that they did not agree with their child's participation in the research. Participants were assured of confidentiality and of the ability to withdraw at any time. No one withdrew during the study. This research

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4 The CSI is a key central institution in the evaluation of the education system in the Czech Republic that distributes and evaluates standardized tests focused on different areas of student learning to measure student achievement in Czech schools.

study followed the ethical guidelines outlined by CERA. All participants were assigned numbers and all personally identifying information was removed from the dataset prior to processing.

Measures

Peer ratings. Data on the position of individual students in their peer social networks are particularly important for this research study. The social networks in individual classrooms were created based on data gathered through standardized sociometric questionnaires designed for small social groups, especially for classes (fifth grade and older) (Hrabal, 2002). Data gathered through sociometric rating questionnaires identify the sociometric positions of students through two dimensions: the dimension of likeability and the dimension of dominance. Likeability was explained orally and in writing with the following formulation: "If we like a person, then we think they are nice and we want to spend time with them. Each one of us can like different people." Dominance was explained orally and in writing with the following words: "If a person is dominant then other people behave as they say and adopt their opinions. Their dominance can be good or bad." The instructions asked the students to identify the dominance of each student. Students were asked to evaluate the degree of likeability and dominance of all their classroom peers, except for themselves. A scale from 1 to 5 was used, where a value of 1 means being the most liked/the most dominant and a value of 5 means being the least liked/not dominant at all. Part of the questionnaire can be seen in Table 1.

Table 1
Sample excerpt of sociometric questionnaire

Name	**Likeability**					**Dominance**				
Anna Berková	1	2	3	4	5	1	2	3	4	5
David Cvrček	1	2	3	4	5	1	2	3	4	5

We normalized likeability into a value of −1 to 1 since values 4 and 5 in the questionnaire represented a negative relationship. A value of 1 represents a score for a student who is perceived by the whole classroom as likeable. The dominance was normalized into a value of 0 to 1, with a value of 1 representing the highest dominance and 0 none, since the values 4 and 5 in the questionnaire represented a low extent of dominance, but nothing with a meaning such as negative dominance.

Centralities. To explore the social prominence of individual students beyond basic sociometric measures, we constructed peer social networks based on likeability ratings between the students (see Figure 1). The sociometric questionnaires allowed us to identify the existence of mutual likeability ties between the individual students within classrooms. A mutual likeability tie was operationalized as a tie between two students who both rated each other as likeable (values 1 and 2 in the original sociometric questionnaires). We assume that, compared to unreciprocated and negative likeability ties, the existence of a mutual likeability tie suggests a mutually acknowledged relationship that facilitates further interaction and social exchange. Four different centrality measures then aim to assess each student's prominence in the classroom based on their relative position within the whole social network of these mutual relationships. While there is a substantial conceptual overlap between the four centrality measures and significant correlations between the centrality measures are present in virtually all networks (Valente et al., 2008), each centrality measure derives prominence of actors based on a distinct criterion.

Degree centrality measures an actor's prominence based on the number of direct links they have with others. In our networks, it is calculated as the number of mutual ties an actor has, and it is normalized into a value of 0 to 1 by dividing the number of the ties by the number of maximum possible ties the actor can have (the number of all students in the classroom minus one). Degree centrality is based on the assumption that direct links lead to greater ability to exercise influence over others.

Betweenness centrality (Freeman, 1977) measures an actor's prominence based on the number of times an actor lies on the shortest path between all other actors. We normalized betweenness centrality into a value of 0 to 1 by dividing the number of shortest paths running through an actor by the maximum possible betweenness centrality value. Betweenness centrality shows the potential of individuals to act as bridges between others. Actors with high betweenness centrality do not necessarily have a high number of direct links but are usually positioned between clusters of actors and/or serve as sole links between otherwise unconnected actors and the rest of the network.

Closeness centrality (Sabidussi, 1966) measures an actor's prominence based on the number of shortest paths originating from an actor to all other actors. In other words, it measures how close any given actor is to all other actors. We normalized closeness centrality into a value of 0 to 1 by dividing the number of the lowest possible number of shortest paths originating from an actor (the number of all students in the classroom minus one) by the actual shortest paths leading from the actor.

Eigenvector centrality (Bonacich, 1987) is an extended–recursive version of degree centrality. It measures an actor's prominence based on how well connected they are to other well-connected actors. In other words, it places importance on both direct and indirect connections. Eigenvector centrality is normalized into a value of 0 to 1 with an actor with the highest eigenvector centrality in network always having a value of 1.

As illustrated by Figure 1, the four centrality measures in our networks do not overlap entirely. On the contrary, even the students with the highest value of one centrality do not necessarily have the highest values of other centralities. In an example below, students with high betweenness centrality scores are not those who have the most direct connections. What they have in common, though, is that they serve as bridging points between otherwise sparsely connected groups. On the other hand, students with high closeness centrality score are located in the core of the network; the more peripheral students are, the lower their centrality scores. Students with high degrees of centrality will almost certainly have high eigenvector centrality as well; however, in some cases, it is possible to have a high eigenvector score with only a few connections, if the immediate connections have many other connections.

Figure 1
Four visualizations of the same exemplary network of mutual likeability ties from our study. Students are colored by values of the respective centrality measure: the darker the color, the higher the value of the centrality measure. Circled students have the highest centrality values in the classroom.

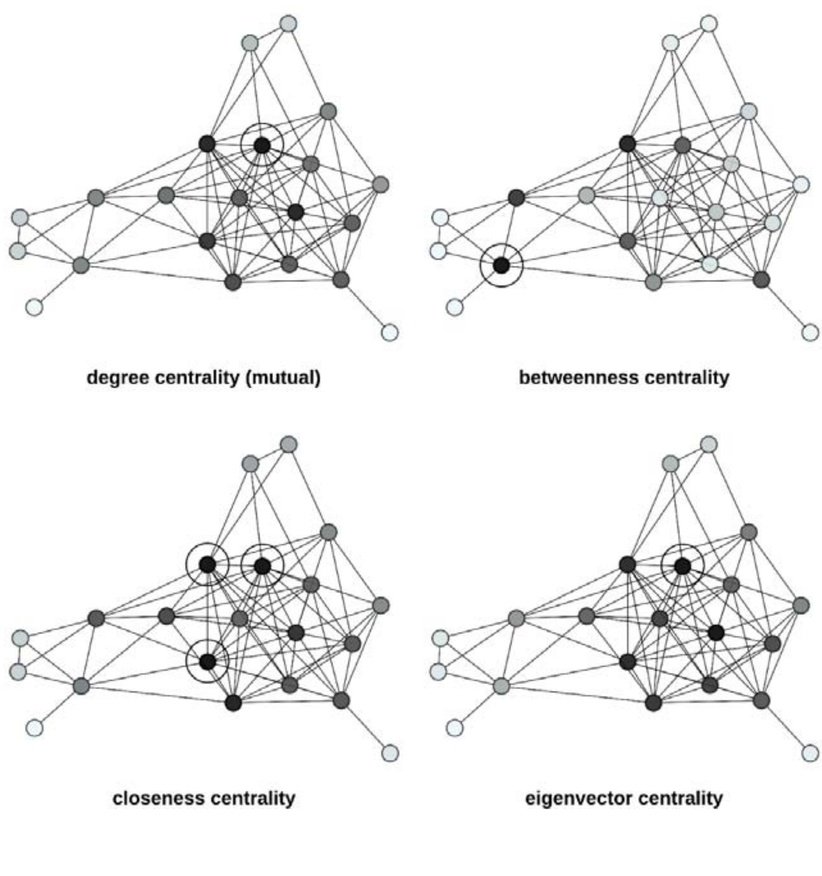


Table 2 shows the sample's descriptive statistics of the studied variables. With the exemption of the betweenness and closeness centrality measures, the data distribution resembles standard distribution. Both betweenness and closeness centrality measures have heavy-tailed distributions, and they are positively and negatively skewed, respectively.

Table 2
Descriptive statistics of the studied variables

	Range	**Mean**	**SD**	**Skewness**	**Kurtosis**
Likeability	−0.79–0.79	0.21	0.29	−0.93	0.85
Dominance	0.01–0.94	0.49	0.20	−0.12	−0.38
Degree centrality	0.00–0.90	0.36	0.18	0.24	−0.38
Betweenness centrality	0.00–0.32	0.04	0.05	2.43	7.16
Closeness centrality	0.00–0.91	0.57	0.14	−1.65	6.19
Eigenvector centrality	0.00–1.00	0.55	0.27	−0.17	−0.95

Seating location. Data on seating arrangements in the classrooms and the location of individual students in their respective seating arrangements are significant for the purposes of this study. Czech school classrooms are typically set up in a traditional way with pairs of students sitting in three distinctive columns comprised of student desks (these columns are known as the window column, the middle column, and the door column). Typically, each column consists of five or six desks. All the desks are oriented towards the blackboard or whiteboard located at the front of the classroom (in the middle) and the teacher's desk (which is placed in the window column of desks). We take the term seating arrangement to visually describe the spatial arrangement of the classroom (and the individual desks present within it), which also includes the names of all the students within that particular classroom.

It is essential to think about how a seating arrangement comes into existence. A limitation of our study was that while we have the seating arrangements of individual classrooms, we did not have access to the information on which of the students chose their seating positions and which of them were assigned one by their teacher. Our study nonetheless stems from the research of Bradová (2012) who described in detail the emergence of a seating arrangement into existence in lower-secondary education. Students can typically choose a location in the classroom during the first day of their lower-secondary education. Teachers tend to adopt a supportive stance in this matter and respect students' choices influenced by their friendship preferences. Teachers thus give students a chance to manifest that they are able to work from their selected location within the classroom. It is this ability that will decide whether they will be allowed by their teacher to keep their seating space. As Bradová shows (2012), if students can work, they can retain their location. However, should that not be the case, and the seating arrangement should be less than optimal from the point of creating possibilities for education, the teacher will introduce changes to the seating arrangement and will start moving individual students to different seating locations. Bradová (2012) notes that teachers are highly aware of the state of the seating arrangements and change the location of individual students to prevent conflicts among them. Once teachers perceive a seating arrangement as optimal, it can stay unchanged for the whole duration of the students lower-secondary education (that is, from sixth to ninth grade). This was also the case in the classes that were observed for this study.

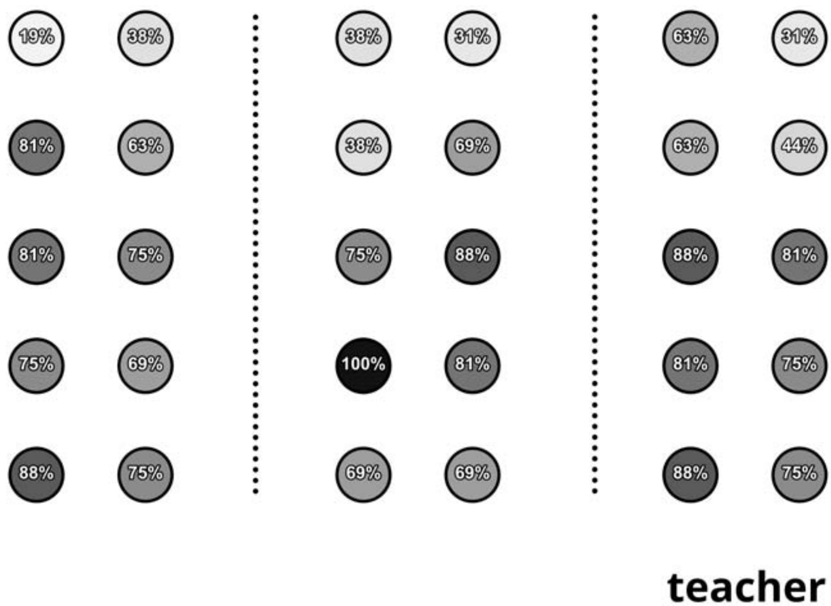
Creation of seating heat maps

Once each student's likeability, dominance, and centrality scores were computed, we projected students onto standardized seating maps representing their seating position within the classroom and colored the students according to their scores of the observed variables, with darker colors representing higher values of the respective variable. This resulted in seating heat maps visually denoting student positions within peer social networks projected into space. The seating heat maps have three double columns (representing shared desks) with two aisles between them, with the number of rows ranging from three to six, and the teacher's desk in the bottom right corner. For each classroom, we created six different heat maps representing students' values of the six observed variables (likeability, dominance, and the four centrality measures) allowing us to explore unique configurations within the individual classrooms.

Afterwards, we created six aggregate seating heat maps for each variable representing the mean value and standard deviation of the respective variable attributed with the individual seating positions, with the individual rows, and with the individual columns. Compared to the seating heat maps of the individual classrooms, the aggregate seating maps aim to provide an overall picture of the relationship between seating positions and positions in peer social networks across the classrooms. Figure 2 shows the percentage of occupied seats across the classrooms. Unfortunately, compared to the rest of the seats, back seats were more often unoccupied. We chose to compute the means (and the standard deviations) in the aggregate heat maps dividing the sum of the values by the number of students occupying a given seat, not by the total number of classrooms, as all seats would be occupied only if all classrooms comprised exactly 30 students.

Figure 2

Percentage of occupied seats



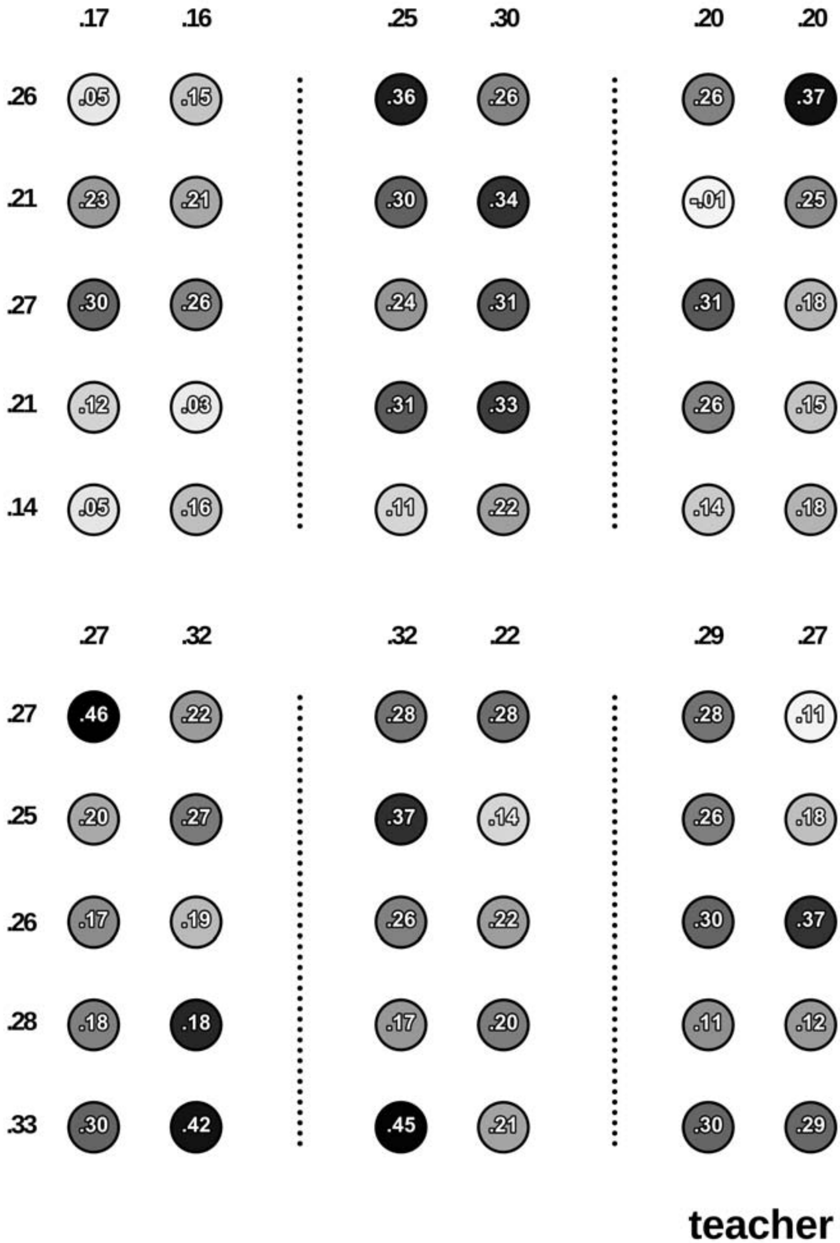
Computing and visualizations were both performed in Gephi software (Bastian et al., 2009).

Selected results

Seating location of likeable students

In order to identify the location of likeable students in seating arrangements, we provide the aggregate likeability score for each student in the individual seating arrangements. The aggregate values can be found in Figure 3.

Figure 3
Aggregate seating heat maps of likeability (top = mean, bottom = SD)



The figure clearly shows that students perceived as likeable sit mostly in the middle column, which has higher aggregate values. An exception to this is present in the first desk of middle column as it is the desk closest to the teacher's desk. There are, however, two exceptions to this finding: the very last desk in the door column and the third desk in the window column. Both represent seating positions on the margins of the classroom and yet students who inhibit these spaces have high likeability scores. This is not a random deviation, and the high likeability of the students is linked to the centrality measures that we also examine in our research and that pertain to the seating arrangement of dominant students.

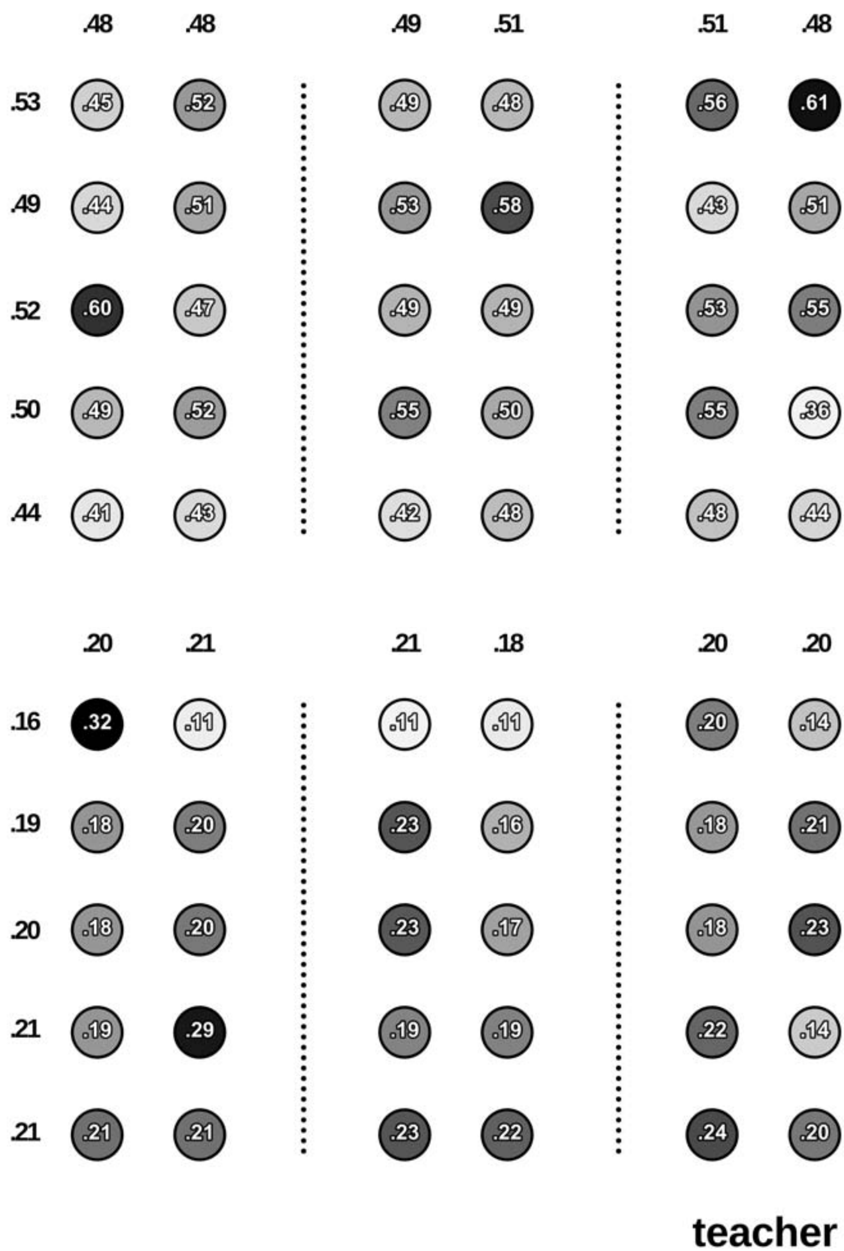
Locations taken by students whom their peers ascribe lower likeability scores can be found in the first desks of all three columns. These low likeability scores also apply to the students sitting in the second rows of both the window and door columns. We explain this drop in likeability by the proximity of these desks to that of the teacher, a position that does not enable the students to interact with their peers during teaching. Such students would have to turn their backs or sides to the teacher to communicate with their peers, which would likely be noticed by the teacher and would be accompanied by at least some reaction from the teacher. These students might find it difficult to communicate even with the other students sharing their desk, assuch communication can be easily detected by the teacher. At the same time, students sitting in the first desks find themselves in the so-called T-zone which means that teachers tend to call on such students more often than on others (Bradová, 2020), which, at their age, can also have a lowering effect on their likeability scores. In sum, both provided explanations can influence the likeability scores of these students.

From looking at the heat maps from the individual classrooms, it is also clear that likeable students are seated close to each other – they inhibit spaces within easy reach of other likeable students. Students with the highest likeability scores vary in their position in the middle column; they typically shared a desk with a student whose likeability score was also high.

Seating location of dominant students

Using the aggregate values, we can also identify the seating locations inhabited by students who are perceived as dominant by their peers. Such seating locations can be found in all the three columns (and by looking at the individual classrooms, we can note that the tendency of likeable students to sit close to each other is not replicated with dominant students). We can also note that locations taken by the dominant students are further away from the teacher, with students seated in the first row on average having the lowest and students seated in the back the highest values of dominance, respectively. On the other hand, locations with low values of dominance can again be found in the first desks in all three columns, as is apparent from Figure 4.

Figure 4
Aggregate seating map of dominance (top = mean, bottom = SD)



If we compare Figure 3 with Figure 4, we can observe that locations with the highest values of dominance in fact overlap with locations with the highest values of likeability. These locations are not represented in all three columns (as opposed to being solely placed in the middle column as is the case with likeable students). This means that they can also be found on the margins of the classroom space. These locations can be seen as an exception to the previous part of this study, which focused on space connected with high values of likeability. Our finding confirms that students to whom their peers ascribe high degrees of dominance are at the same time ascribed high values of likeability (cf. Šalamounová & Fučík, 2019). Nonetheless, these (dominant and liked) students sit in different locations than, for example, students who are perceived "only" as likeable.

Spaces inhabited by likeable students are in close proximity to one another. In contrast, when we look at the individual classrooms, the locations inhabited by dominant students are positioned further apart. This means that isolated dominions can be seen dispersed throughout the classroom.

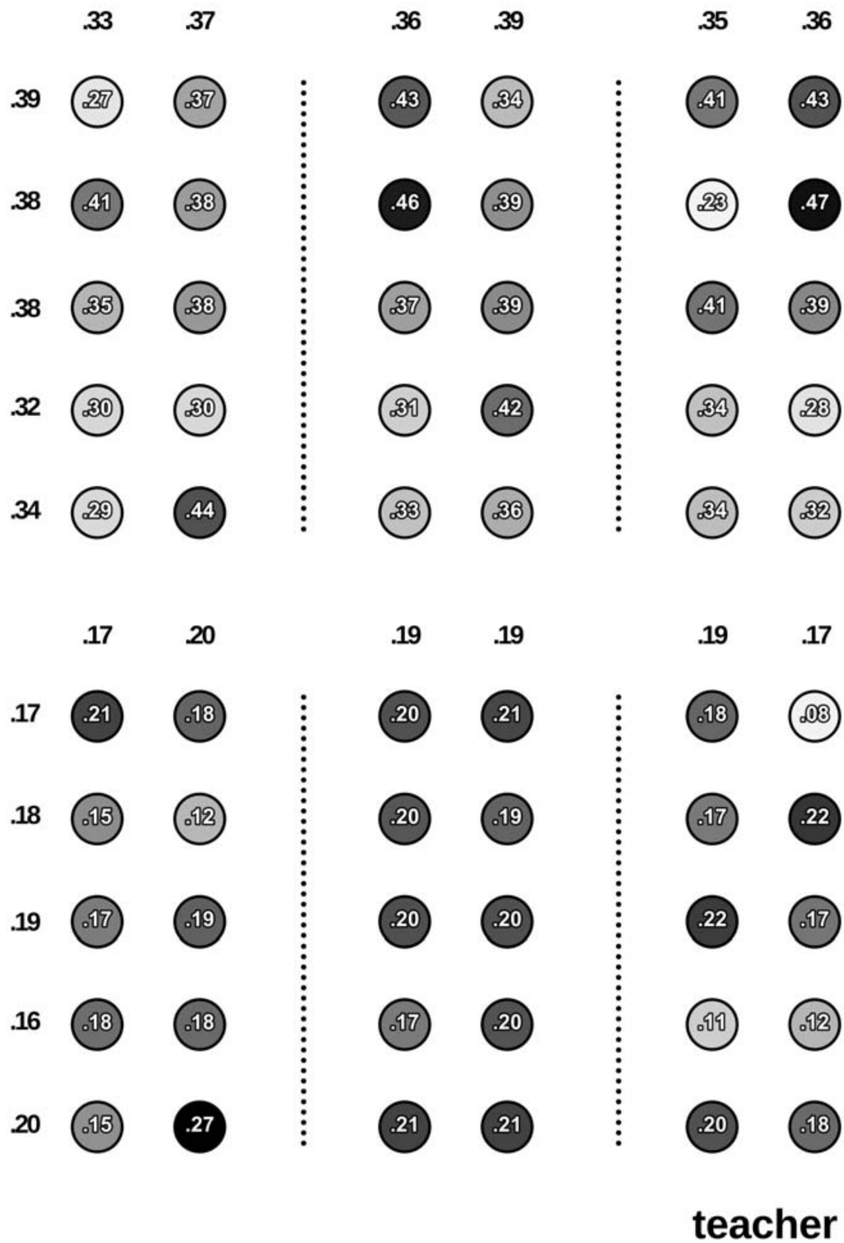
The three locations with high occurrence of dominant students are equally far from the teacher's location in the classroom (which can typically be found in front of the first row of desks and in front of the aisle between the middle and the door column). We explain this occurrence by pointing out that students with high dominance index communicate more frequently with their teacher (Šalamounová & Navrátilová, 2021). Even though there is a certain distance between them and the teacher, they are not located very far away from the teacher, as that would prevent their mutual communication.

Seating location of students with degree centrality

If we turn our attention to the connection between individual classroom space and the number of direct links expressed through the degree centrality, we can notice an increase in values in spaces located further from the teacher; a decrease in values can be observed in the first and seconds desks of all the columns. Nonetheless, increased values can be found in all three columns and are again not solely positioned within the middle column, as is the case with likeability. The distribution of spaces and their connection to the degree of centrality is shown in Figure 5.

We can thus state that is not only the likeable students seated in the middle column who have positive mutual relationships with their peers, who show their peers sympathy and receive it in return; even other students not seated in the middle column have such relationships with their peers. This is also the reason that the degree of centrality is distributed more evenly through the seating arrangement and is not represented exclusively by the students seated in the middle column.

Figure 5
Aggregate seating map of degree centrality (top = mean, bottom = SD)



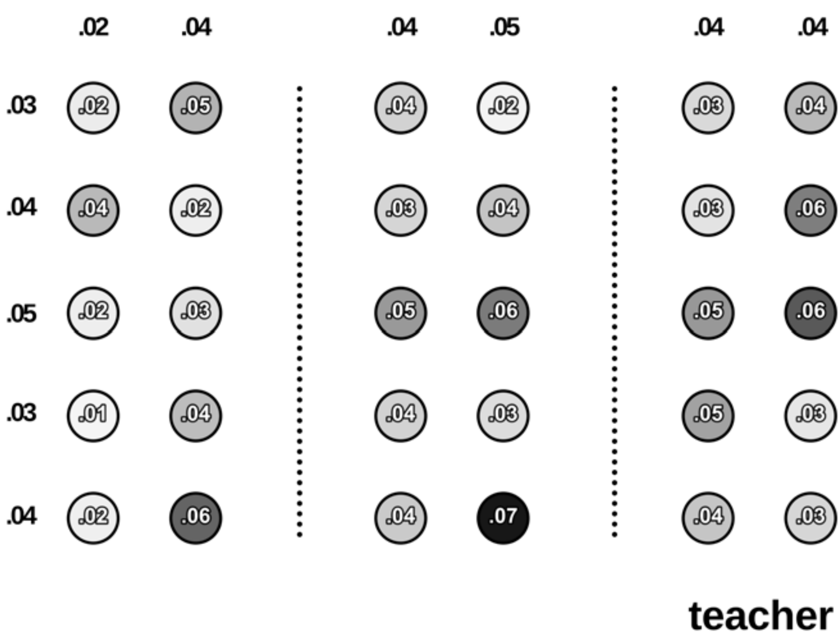
Students seated in the first two desks in each column can have fewer relationships with their classroom peers. However, the figure also shows that this trend might not be valid at all times. We explain the higher degree of centrality in locations positioned further away from the teacher by the fact that these spaces enable the students to have easier communication with their peers, even when those peers are not seated in the same desks. Spaces in front of the teacher do not come with conditions that enable non-educational communication during teaching.

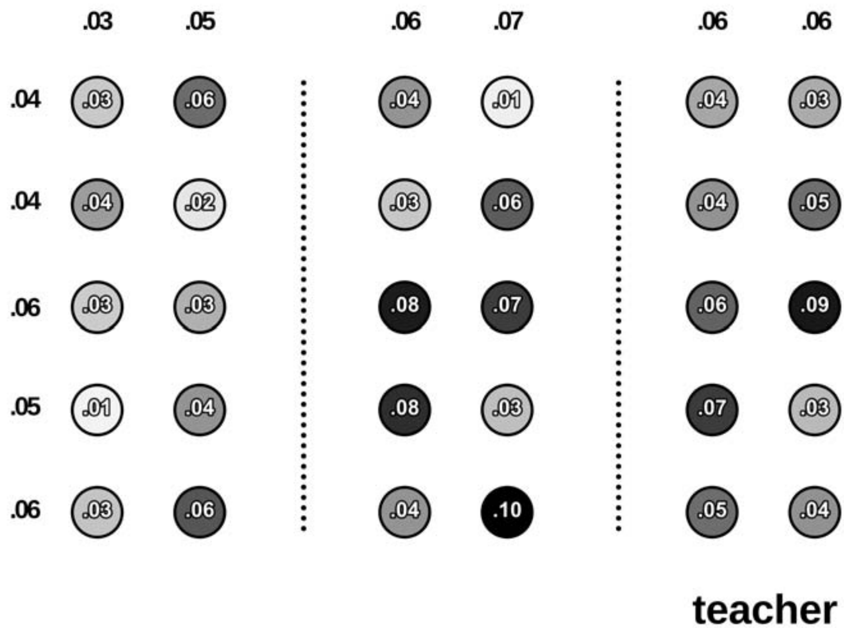
Seating location of students with betweenness centrality

When it comes to betweenness centrality, locations positioned further away from the teacher are not associated with higher values, as we have seen previously. On the contrary, high values are associated with spaces in the front desks and in the middle row, as both the aggregate and the individual classrooms heat maps attest. Further, spaces with high values for betweenness centrality are found in the middle desks of the middle and door column. The respective values are shown in Figure 6.

Figure 6

Aggregate seating map of betweenness centrality (top = mean, bottom = SD)



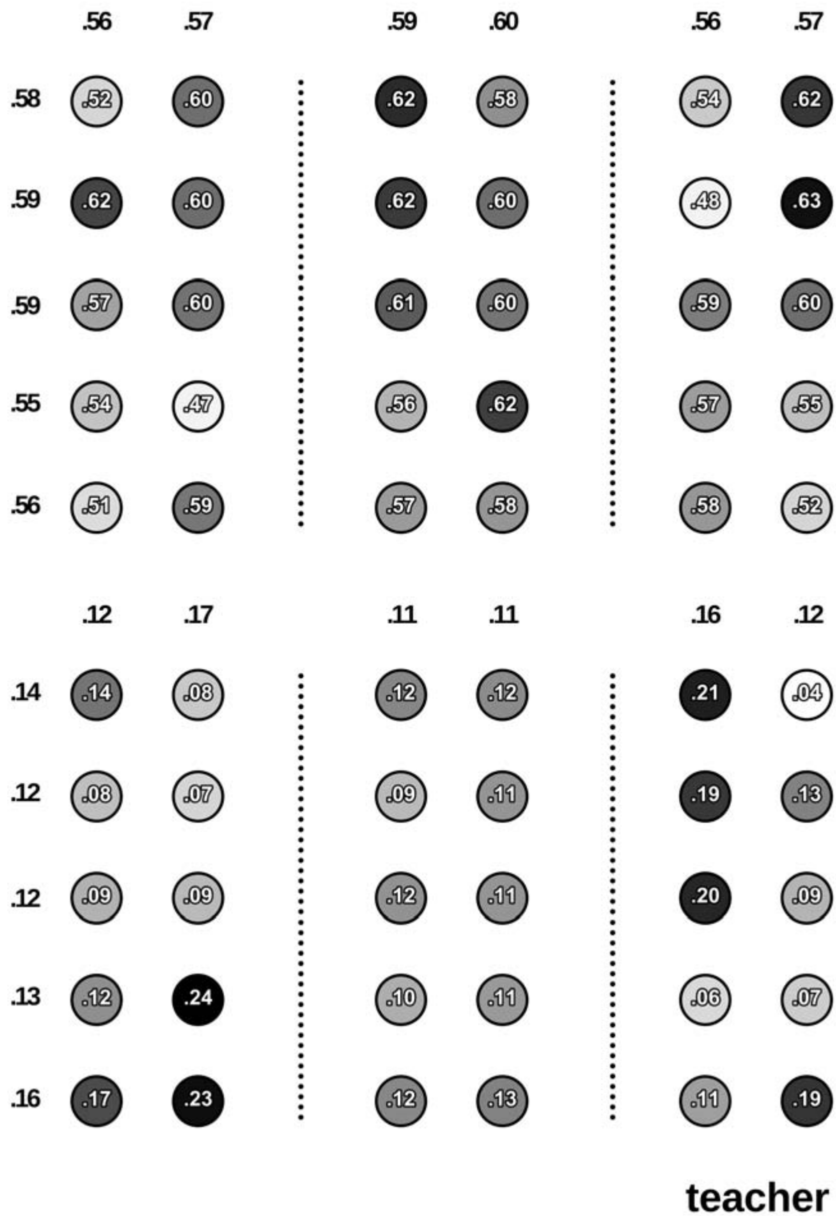


This can indicate that students who interconnect various groups in their classrooms might have fewer direct relationships (which is clearly the case of the spaces with the highest values in the middle desks of the middle column). This shows that students who interconnect various student groups can be seated in spaces linked with fewer direct relationships. Nonetheless, even when such students do not occupy the very centers of various student groups, they can interconnect different groups well thanks to their non-central positions.

Seating locations of students with closeness centrality

The aggregate data on closeness centrality clearly show the highest values located in the middle column, which does not include a single space with low values. The differences between the front and back desks are minor. Spaces with lower values can be found in front spaces on the margins of the classrooms. Yet the results are still rather homogenous.

Figure 7
Aggregate seating map of closeness centrality (top = mean, bottom = SD)

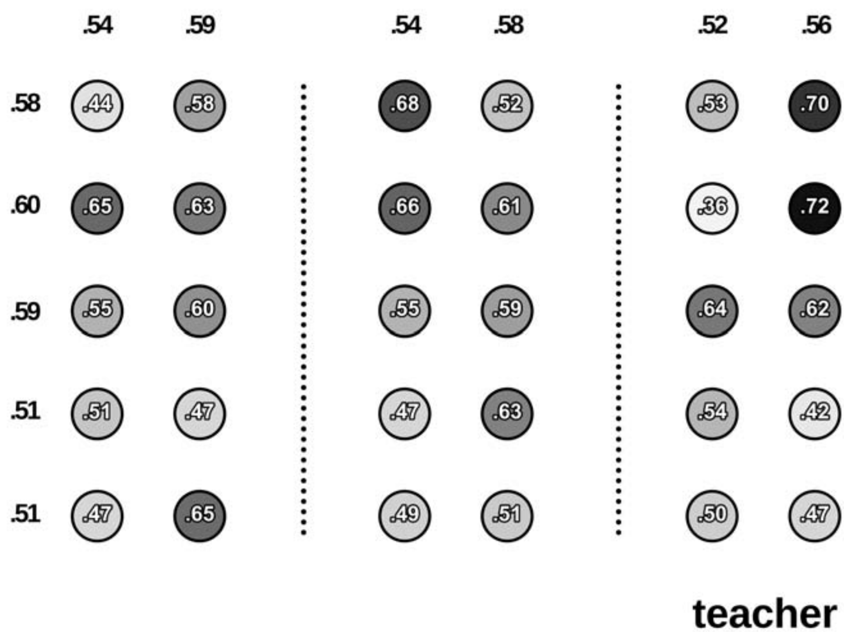


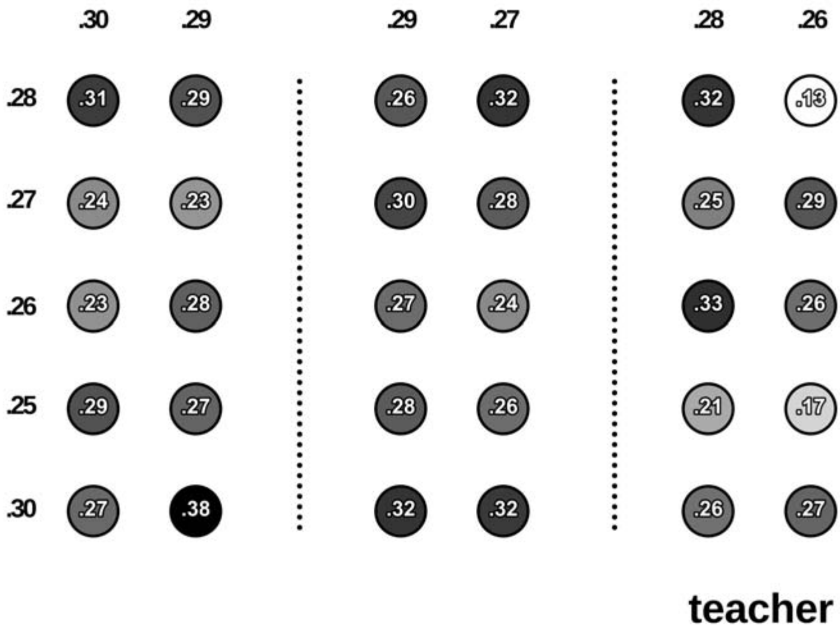
Seating location of students with eigenvector centrality

The last observed value relates to the eigenvector centrality, which specifies whether individual nodes in a network have relationships to others through the closest node to which they have direct links. It is therefore possible that even a node without many direct links can have a high value of eigenvector centrality. Our data show that the dispersal of values in the classroom seating arrangements points to a similar dispersal as we saw with the degree centrality. We again see an increase in desks positioned further away from the teacher while spaces associated with higher values can be found in all three columns, as Figure 8 shows.

Figure 8

Aggregate seating map of eigenvector centrality (top = mean, bottom = SD)





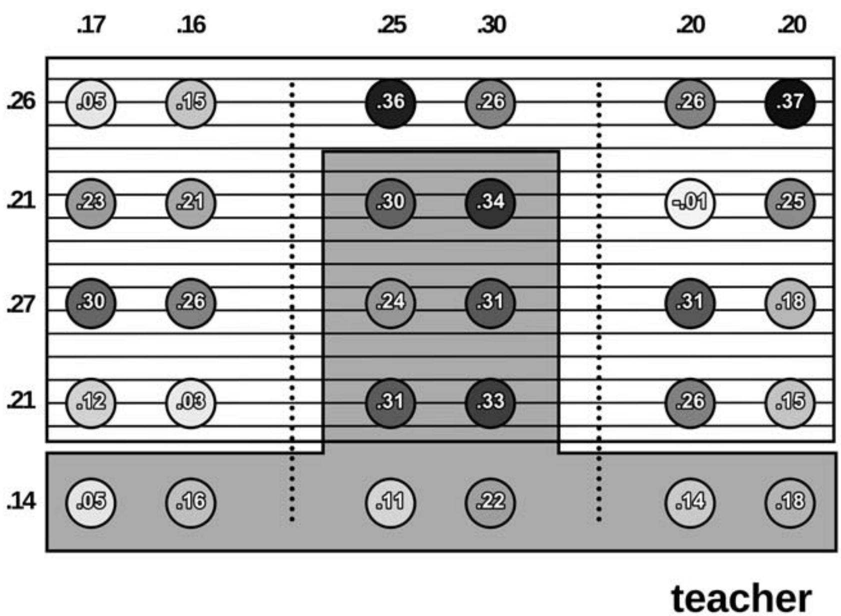
If we interpret both the values for degree and eigenvector centrality, it becomes clear that spaces in the front desks are associated with a lower number of direct positive links among students. It also becomes clear that these links lead to other students who also have fewer direct positive links to their peers. It therefore follows that students in the front desks have primarily relationships with other students from the front desks who surround them as they also have lower values of eigenvector centrality. This finding thus corresponds with the findings of van den Berg and Cillessen (2015), according to which relationships occur among students who are seated closer to each other.

Seating locations for learning and mutual relationships

Empirical evidence indicates that variables related to seating arrangement or seating position can impact educational interactions (Bradová, 2011, 2020; Jones, 1990; Marx et al., 1999). If we interconnect the studies that examine seating arrangement from the perspective of student participation in classroom discourse with the results of our study—which explores how seating arrangements may be associated with social relationships among classmates—we can summarize that there are several specific zones in which students can be seated. There is a zone that provides students with more opportunities for learning (the so-called T-zone, rendered in gray in Figure 9). Also, there is a zone in which students have more positive mutual relationships than students seated in the first desks of all three columns (rendered with horizontal lines in Figure 9). The middle column (without its first and last desk) is the overlap between these two zones (rendered in gray and horizontal lines in Figure 9).

This location can be understood as the most advantageous position in the seating arrangement, since students seated in these desks are given more opportunities to participate in educational communication. They also have, at the same time, more positive mutual relationships and they are ascribed the highest values of likeability out of all the students. This space is therefore advantageous both from the perspective of peer relationships and academic achievement.

Figure 9
Different zones laid over aggregate seating map of likeability



Summary and discussion

The aim of this explorative research study was to identify the relationship between the positions of individual students in their peer social networks and their classroom seating arrangement through sociometry and social network analysis. Clearly, positions in peer social networks cannot be automatically connected with specific seating positions. Nonetheless, certain tendencies can be observed.

Ascribed likeability is represented the most in the middle column (with the exception of its first desk). We consider this finding to be interesting especially in the context of data on students' location and their degree centrality. From analyzing the individual classrooms, it follows that students who are perceived by their peers as likeable do not have more positive mutual relationships with others. In other words, ascribed sociometric likeability does not show that these students automatically have more relationships since higher values for positive mutual relationships are dispersed through all the three columns (with the exception of the first and second rows). Apparently, students have positive relationships with other students no matter whether their peers sit in the window, middle, or door column. Yet, if asked to identify the likeability of their peers, they ascribe higher values to students sitting in the middle column (with the exception of its first and last desk). It is possible to deduce that students inhabiting these central desks are situated close to other students who surround them on both sides. As such, these students can be more easily seen and heard by their peers. Locations with positive mutual relationships among peers are distributed throughout all three columns with the weakest values detected in the first rows (and partly also in the second rows). Bradová (2012) points out that the first and second rows are indeed unpopular among students. The surveyed students explained this with a lack of privacy; students in the window column felt that their actions were easily scrutinized by the teacher, and students in the door column seated next to the washbasin complained about higher levels of noise. The lower centrality values associated with these spaces then present another reason why these spaces are disliked. As Bradová (2012) points out, students inhabit these spaces simply because they have to (for example, they would not see the writing on the board were they seated elsewhere) and not because they want to.

The lowest values measured in the first and second desks can also be explained taking the eigenvector centrality into account. Students seated in these desks have relationships with the peers who surround them and also inhabit the first and second desks. Such students also have low levels of eigenvector centrality. This finding is affirmed by the findings of van den Berg and Cillessen (2015), which show that students have mutual relationships with other students who are seated close to them. The authors of the study claim that people who interact with each other think more positively of one another. They also ascribe each other higher values of likeability, which is a finding that is applicable to classroom students as well.

If we examine the seating arrangement through the perspective of dominance, we can state in accordance with Babad and Ezer (1993) that high values are associated with spaces situated at the back of the classroom. From analyzing the individual classrooms, we can state that such spaces are distributed throughout the classroom, which means that students with high values of dominance are not seated close to other students with similarly high values, as is the case with likeability. Instead, dominant students are located in some kind of dominions that spread around them and do not include similarly dominant students. Our study was limited by the fact that we did not have access to data on how the seating arrangements came into existence. There are two possible explanations. First, the distance between individual dominant students can be motivated by their own choice since they prefer not to be close to other dominant students. However, their position can also be explained as the decision of the teachers who distribute dominant students throughout the classroom to prevent either friction or accumulation of their dominance.

It is interesting to realize that dominant students are not necessarily located in the places furthest from the teacher. Two possible explanations are available. Or previous study (Šalamounová & Navrátilová, 2021) shows that dominant students tend to be very communicative and engage with the teacher even without an invitation to do so. At the same time, they also prefer to communicate with their peers. This could explain the dominant students' avoidance of desks at the back of the classroom, provided they have chosen their seating position themselves. If they find themselves seated in these spaces because of the teacher, this can be motivated by the teacher's wish to more easily monitor their actions and interact with them if necessary.

A question arises as to how these findings can be implemented into teaching practice. Since teachers are in control of seating arrangement in their classrooms, they are in control not only of the learning opportunities given to their students but also of their relationships with their peers, and of their position in the social network of their classroom. They could consider the option of systematically changed seating arrangements in which students would not inhabit one particular space. The findings of Bradová (2020) speak against such a possibility, since her study shows that students do not wish to change the seating position that they themselves chose at the beginning of the school year. We therefore believe that particular procedures should be devised for particular classes of students. We believe that the awareness of how seating arrangement can influence student relationships can enable teachers to reduce "cliques and cleavages" and to improve the social integration of isolated and rejected children (Gest & Rodkin, 2011) so that students have good opportunities not only to learn but also to create relationships with their peers.

Our study has limitations. The first limitation is presented by the asymmetric unoccupied seats across the rows, with back rows having a disproportionately higher percentage of unoccupied seats. This study does not consider a possibility that (un)occupancy of seating places also relates to the resulting variable values. In other words, we see (un)occupancy as a nuisance resulting from uneven numbers of students, rather than a state related to social processes among the students. The second limitation lies in its temporary access to seating arrangements of students during the data collection phase of the study. As Bradová (2012) shows, seating arrangement can undergo changes and fluctuations during the school year at the behest of the teacher who can change the arrangement to create better conditions for learning in the classroom. Our study worked with the end result of this process: with the stabilized seating arrangement in the final grade of lower secondary schooling. We did not have access to data on the creation, its gradual changes, and its causes, which are all important factors that could be explored in future research on the classroom.

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Corresponding authors
Tomáš Lintner
Department of Educational Sciences, Faculty of Arts, Masaryk University, Brno, Czech Republic
E-mail: tomas.lintner@mail.muni.cz

Zuzana Šalamounová
Department of Educational Sciences, Faculty of Arts, Masaryk University, Brno, Czech Republic
E-mail: salamounova@phil.muni.cz