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Construction of an Interactive Network for Teaching Physical Education in a Digital Web Analytics Model

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ABSTRACT

In educational research, more and more scholars recognize the importance of teaching interaction network for learning, and they find that "interaction" is not only the method of learning, but also the learning process itself. Social network analysis provides a new way to study teaching interaction. Through the study of social network analysis, this paper proposes the construction method of teaching interaction network for physical education. In this paper, we take four real physical education courses in L school as the research object to conduct in-depth research, obtain the physical education classroom teaching interaction behavior data, and construct the teaching interaction network. The results of the study show that in the interaction network of the four physical education teaching courses, the teaching behaviors of the community network of physical education classroom 1 are significantly concentrated in B3, B4, B5, and B6, course 2 is concentrated in B4, B5, B6, B9, and B10, the teaching interactive behaviors of physical education classroom 3 are significantly concentrated in B2~B6, and the significant physical education teaching interactive behaviors of course 4 are concentrated in B2, B4, B5, and B6.From the degree-centeredness analysis, there are 33 marginal learners with the number of stored interactions less than or equal to 2 in physical education teaching interactions, which indicates that in this paper's study of physical education teaching interactions, teachers do not pay enough attention to teaching interactions in a comprehensive way. By summarizing the theoretical basis and practical significance of teaching interaction and social network analysis, it proves that the network construction of teaching interaction in this paper is effective, and at the same time, it also provides a new idea for physical education teaching courses.

Keywords: social network analysis, physical education, teaching interaction network, interaction behavior

1. Introduction

Traditional physical education is often based on the teacher's one-way teaching, in order to improve students' learning interest and participation, physical education interactive is widely used. With the development of the Internet, the interactive network of physical education has entered the field of

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education.

Physical education interactive network supplements the single teaching content in the traditional teaching classroom, through the network to expand the teaching content of the physical education classroom, as a kind of extension of the basic physical education class, teaching related sports health care content, sports competition appreciation, etc. [1-2]. Physical education interactive network adopts various forms of network, breaking through the time and space limitations of the traditional teaching classroom, combining the advantages of traditional teaching and then more convenient and efficient, students' learning opportunities have been increased, the scale of the school's teaching has been expanded, and the cost of physical education has been reduced [3-5]. Students can learn independently through the interactive network of physical education, freely choose the appropriate time and place, and independently control the mode and speed of learning, which improves the relevance and effectiveness of physical education [6-9]. This resource-rich and time-independent new type of teaching expands the scale of learning and increases the feasibility of lifelong physical education. It can be said that the interactive network of physical education improves the teaching effect. In addition, the interactive network of physical education enables students to grasp knowledge more firmly and master more contents, so as to cultivate students' real physical education ability. At the same time, the reusable network resources can promote students' digestion and absorption of knowledge, so that the skills can be mastered more firmly, and improve the sports ability [10-12]. The interactive network of physical education can collect the feedback from students and teachers internally and externally. Through the Internet network, teachers can also recharge their batteries in time, learn from the advanced experience of other schools, and communicate with other schools remotely in real time to improve their teaching ability [13]. Physical education interactive network is conducive to the establishment of a positive and healthy educational relationship, this new type of educational relationship can greatly play the educator and the learner's subjective consciousness, so that they give full play to their enthusiasm, initiative, self-consciousness, initiative and creativity in education and teaching, and promote conscious innovation and reform of education [14]. However, in the network background, the resource information is complex, and the interaction of physical education teaching lacks guarantee. Therefore, an interactive network can be designed for physical education teaching [15].

In terms of the objects and participants of teaching and learning, teachers and students are the necessary parties involved in teaching and learning, and the interactive behavior between teachers and students is necessary to ensure the production of teaching and learning. Social network analysis is the process of using networks and graph theory to study social structure, and its application in analyzing interactive behaviors has become more common. Based on this, this paper launched a study on social network analysis methods and proposed an interactive network application process for physical education teaching based on social network analysis. On this basis, the physical education teaching course in L city was used as an example to collect data on teaching interaction behavior, constructed a physical education teaching interaction network, and analyzed its interaction behavior to provide research data for the study of physical education teaching interaction behavior.

2. A Study of Physical Education Teaching Interaction Based on Social Network Analysis

2.1. Social network analysis

As a relatively mature analytical method in the field of sociological research, social network analysis is a quantitative analytical method developed by sociologists based on mathematical analysis, statistical methods and graph theory, which is very suitable for analyzing and explaining some common sociological problems.

A network is a structure in which nodes are connected by interconnections, and a social network is

a structure composed of many individuals through social relationships. Social network analysis (SNA) has its origins in adaptive networks in physics, and by analyzing social networks in depth, it facilitates the integration of relationships between individuals, the "micro" structure of the network, with the "macro" structure of large-scale social systems.

From the social network point of view, the interactions of individuals in the social environment are expressed as a rule based on relationships, and it is from the regular pattern of such relationships that the social structure emerges. The starting point of social network analysis is the quantitative analysis of this structure. The main components of a social network include:

1) Participating individuals, which can be a specific person, a group, a company, or any other social unit. Each participating individual's position in the network is a node.

2) Relational ties, the association between each pair of participating individuals is a relational tie. Relationships between individuals are various, such as cooperation, confrontation, kinship, exchange, etc., which can form different relationship ties. Each relational tie is a link or edge in the network.

An in-depth analysis of the relational structure and properties of social networks can easily lead to a set of feasible norms and methods, which is called social network analysis.

In order to better mimic and explain the evolutionary and generative laws of real networks, scholars have tried to propose various models to reproduce the actual network complexity.

The ER model is briefly summarized as having N node, and any two nodes are connected with probability p so that a random network containing N nodes and $pN\times(N-1)/2$ edges can be generated with an average degree of $p(N-1)$.

Scholars have been studying stochastic networks for a long time, and the results have been quite fruitful. One of the most important physical phenomena that scholars have discovered is that the network undergoes a phase transition as p approaches $1/N$. That is, if $p<1/N$, the size of the extremely large clusters is of the same order as $\log(N)$, but when $p>1/N$, the size of the extremely large clusters is of the same order as N.

The average pitch height of a random network is satisfied with the network size:

$$L=\frac{\log N}{\log\left[p\left(N-1\right)\right]} \tag{1}$$

The average distance of the random network is small, but the degree distribution satisfies the Poisson distribution, and the agglomeration coefficient is not high, which is inconsistent with the characteristics of the actual network. It can be seen that the random network can not be used to describe the actual network, nor can it be used to describe the generative evolution law of the actual network.

In real life, both regular and random networks cannot be used to characterize real world networks, because most of the real networks are neither regular nor random, but appear to be random but hide universal laws. 1998 constructed a network model with small-world characteristics, the small-world characteristic expresses the fact that in the real world, although the size of a large number of networks is very large, but the distance between two nodes is very small, and the distance between them is very small. In the real world, despite the large size of a large number of networks, the distance between any two nodes is very small. The "six degrees of separation" theory of social networks verifies this fact. Much like real social networks, small-world networks have a high coefficient of agglomeration in addition to a small average distance.

Based on the growth and preferential connection characteristics of the network, a construction method is proposed to obtain the BA scale-free network model with the following steps:

Step 1: Growth. At first the network contains m_0 node, each time a new node is added, m existing nodes are selected for connection with a certain probability $\left(m\le m_0\right)$.

Step 2: Prioritize connections. The probability p_i that a new node is connected to an existing node v_i is proportional to the node degree k_i, i.e:

$$p_t = \frac{k_i}{\sum_{j=1}^{N_i} k_i} \tag{2}$$

where $N_i = t + m_0$ is the number of nodes after t times of growth and the corresponding number of edges is mt.

With the passage of time, based on growth and merit selection, eventually the network will reach the state of scale invariance, i.e., the degree distribution is stable and unchanged, and the probability of a node with degree value of k is computed to be positively proportional to the Muzzy term $k-3$.

The two mechanisms of growth and merit-based connectivity contribute to the formation of Hub nodes. New nodes are more likely to connect to nodes that already have more connections, and thus these nodes have more connections than other nodes, which is a kind of "rich-get-richer" process that contributes to the formation of Hub nodes.

2.2. Methods for analyzing social networks oriented to physical education interaction

A social network is a large collection of various social actors and their interrelationships, not just a simple link between people, but a multilevel, multidimensional system. Its basic building blocks are the actors and the relationships that exist between them. The characteristics of interaction in physical education studied in this paper do not only indicate the existence of relationships, but the arrows indicate the inflow and outflow of different modes of interaction. If based on the degree of closeness of the relationships, the relationship diagrams can be categorized into binary, symbolic and assignment diagrams. Binary value diagrams indicate the presence or absence of a relationship, an either/or relationship, and symbolic diagrams indicate good, irrelevant, or bad, an either/or relationship. Assignment graphs, on the other hand, assign values according to the strength of the relationship, and generally the larger the value the stronger the relationship. Therefore, social networks can be used to study the characteristics of physical education interaction behavior. Considering teachers as nodes and their interactive behavioral relationships as connecting lines, the matrix is transformed into a flow network of interactive behavioral characteristics using social network analysis and visualized, which can be more intuitively found out their teaching interaction characteristics.

1) Network density. Network density is used to describe the degree or strength of connection between nodes in a network. Network density is usually expressed as a percentage or decimal, indicating the ratio of the number of established connections to the number of possible connections in the network. It provides information about the tightness of the network. The greater the network density, the tighter the connections between the executive mobility networks and the greater the impact produced by the network. The formula for a directed network is:

$$D = \frac{m}{n(n-1)} \tag{3}$$

Where, D denotes the network density, n is the number of nodes and m is the number of established connections.

As a rule of thumb, social network densities usually range from 0.1 to 0.3. If the network density exceeds 0.3, it can be regarded as a relatively tight network. If the network density is lower than 0.1, it can be regarded as a relatively sparse network.

2) Average Path Length. The average path length indicates the number of edges that need to be traveled from one node to another in a network. In simple terms, it measures the distance or connectivity between nodes in a network. In UCINET, the distance is calculated with two parameters. Average distance and distance based cohesion index (compactness). Average distance means that any point can reach another point on average through that path length. And the distance-based cohesion index is the

inverse of the reconciled mean of all elements (i.e., the arithmetic mean of the inverse of all distances).
3) Node centrality:

(1) Point Degree Centrality. Point degree centrality is an index used in network analysis to measure the degree of importance of a node in a network. It measures the number of connections between a node and other nodes in the network. In a network, the higher the dot centrality of a node means the more connections it has with other nodes. In directed networks, the point degree count can be categorized into in-degree and out-degree. Point in-degree refers to the number of other points flowing to that node. Point out degree refers to the number of other points flowing out of that point to other nodes. There are two types of point-degree centrality of a node:absolute centrality and relative centrality, the former refers only to the degree of a point, and the latter is a normalized form of the former.

(2) Intermediary centrality. Intermediary centrality is an indicator used in network analysis to measure the degree to which a node acts as an intermediary for information transfer in a network. In the network, the higher the intermediary centrality of a node, it means that it plays an important bridge or transit role in the network, only through the node, the information or resources can be more easily transmitted in the network.

(3) Proximity centrality. Proximity centrality is a metric used in network analysis to measure the length of the shortest path from one node to other nodes. In a network, a high proximity centrality of a node indicates that it is closer to all other nodes in the network relative to other nodes, and therefore has higher accessibility.

4) Core-Edge Model Analysis. The purpose of core-edge structure analysis is to quantify the core-edge patterns manifested in the phenomenon. Discrete models are mainly used to analyze the core-edge structure of the data. Continuous models are mainly used to analyze the core-edge structure of network data and give the core degree of each node.

5) Coalescent subgroup analysis. The purpose of cohesive subgroup analysis is to discover the subgroup structure in the network and reveal the structural features. In performing cohesive subgroup analysis, there are several specific steps, i.e., binarization processing-component analysis-subgroup analysis-subgroup overlap pattern analysis. Overall, these steps adhere to the analysis logic: start with loosely defined and easy-to-find subgraphs, and gradually analyze the strictly defined and difficult-to-find subgraphs.

2.3. Social Network Analysis Process for Physical Education Oriented Interactions

The process of social network analysis for physical education interaction is shown in Figure 1, and the research process of social network analysis is composed of seven modules. The social network analysis of interaction behavior in physical education classroom needs to start from the perspective of social network analysis and design the corresponding interaction behavior hierarchy specifically for physical education teaching, so as to clarify the classification of interaction behavior in physical education classroom environment, what is the difference between interaction behavior in physical education classroom environment and other teaching contexts, and how can interaction behavior in network synchronous classroom environment be classified into several interaction dimensions, and how do the interaction dimensions correspond to the interaction behavior hierarchy in network synchronous classroom environment? behavior can be classified into several interaction dimensions, where how the interaction dimensions correspond to the interaction behavior hierarchy. Designing a hierarchy of interaction behaviors in a synchronous environment based on social network analysis provides a reference model for the study. The analysis of social structure requires the use of social network analysis methods, and there are various perspectives of analysis, some studies are based on the analytical steps from concrete to abstract, and some studies are based on the analytical steps from abstract to concrete. Thus, the analytical steps of the study can be decided on the basis of density, centrality, cohesive subgroups, the core-edge model and the level of abstraction of the community

graph.

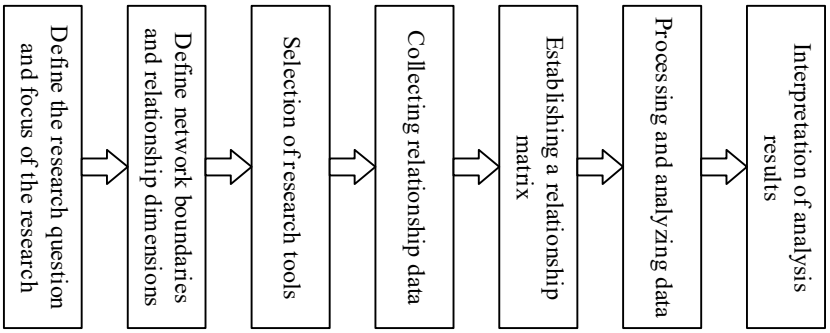

Fig. 1. Social network analysis process for physical education interaction

3. Construction of Interactive Network of Physical Education Teaching Based on Social Network Analysis

The research object of this paper is the real physical education teaching program of School L in 2023, which contains 4 physical education teaching lessons. In this paper, we selected two male teachers and two female teachers with rich teaching experience in this school, all of whom are between 30 and 40 years old, and recorded the video with the consent of the teachers and students. The video was recorded in three camera positions: the teacher's position, the student's position and the panoramic view of the classroom, so as to cover the whole scene of teaching. The interactive behaviors of physical education were classified as 16 kinds of behaviors: accepting feelings, praising and encouraging, accepting students' claims, asking questions, explaining, giving guidance, maintaining authority, using tools, facilitating communication, students' passive speech, students' active speech, students' speech, students' collaboration, students' use, students' creation, and silence or confusion, which were recorded as B1~B16.

3.1. Descriptive statistical analysis of interactive behaviors in physical education

Descriptive statistics of the frequency of occurrence of interactive behaviors in physical education is the most intuitive representation of the application of various types of interactive behaviors in physical education. This study is based on the adopted OKC software for observation and the GSEQ tool was used to automatically perform the statistical analysis of the data of the interaction behaviors in the physical education courses, and the results of the statistical analysis of the teaching interactions are shown in Figure 2. The three behaviors that occurred most frequently in PE course 1 were B3 (25), B4 (35), and B5 (26), i.e., the interaction behaviors of accepting students' assertions, teacher's questions, and teacher's indirection were the three types of interaction behaviors that were most applied by the teacher in that classroom. The frequency of silence or disorganization occurrence is also high, indicating that the classroom has many times of silence or disorganization occurrence. The three behaviors B4, B5, and B6 with the highest frequency occurred in PE course 2, B4, B6, and B10 in PE course 3, and B2, B4, and B11 in course 4. Taken together, the interaction behavior of questioning by the teacher in B4 has a high level of frequency occurring in all four classrooms, which indicates that questioning interactions of the teacher are more important in the PE classroom. At the same time, the classroom may produce many silent behaviors, and the comprehensive view of the content of the teaching video shows that the teacher usually produces certain silent behaviors after asking questions and explaining.

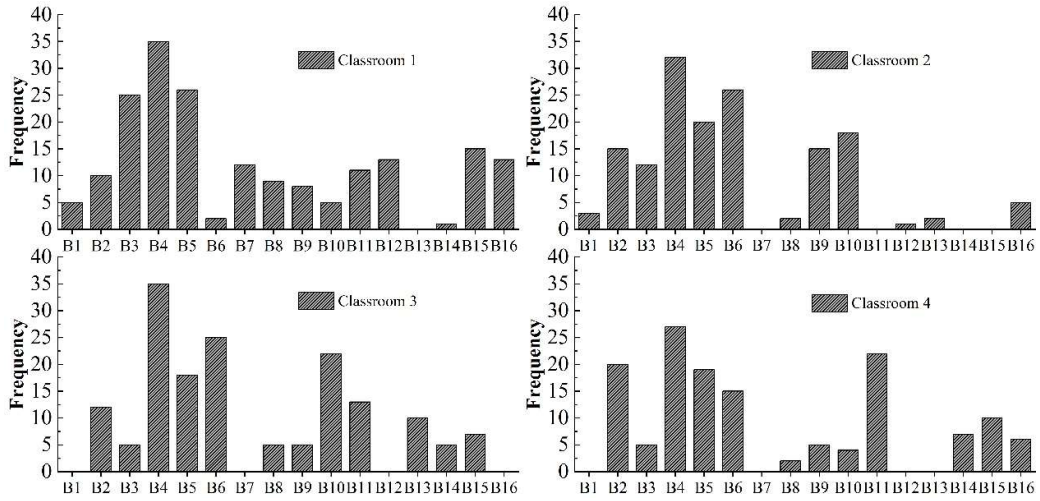

Fig. 2. Interactive statistical analysis results

3.2. Interactive Behavioral Networks for Teaching Physical Education

Social Networks Community Graph Analysis In a community graph, nodes and connecting lines can be used to represent the interaction relationship between nodes in the whole social network. In the community graph, nodes represent actors, and the connecting lines between nodes represent the interactive behavioral relationships between actors, and the community graph is a directed graph, so it can visualize the interactions of the nodes. In community graph construction, the complexity of the nodes can make the graph difficult to deconstruct and understand, in this paper the teaching behavior distribution has a total of sixteen interactive behavior nodes, the study sequentially imported the classroom data into UCINET, and NetDraw was used to draw the sports teaching interactive behavior network of each teaching video.

The results of the network construction of teaching interaction behaviors for Course 1 are shown in Figure 3.The significant teaching behaviors in the community network construction of PE Classroom 1 are concentrated in B3, B4, B5, and B6, which are located in the core of the social network of this community graph, indicating that throughout the teaching of PE classroom, the teaching interactions between the teacher and the students are mainly focused on asking questions, explaining, and giving guidance or instructions. In the community graph, instructional behaviors B1, B7, B12, B13, and B15 were at the edge of the network, indicating that teachers did not focus on the use of these interactions in teaching. Meanwhile, B8, B9, B10, B11, and B14 were more frequent, indicating that the teacher paid attention to the activities of student interaction in this lesson, and therefore the students had more opportunities to practice and manipulate.

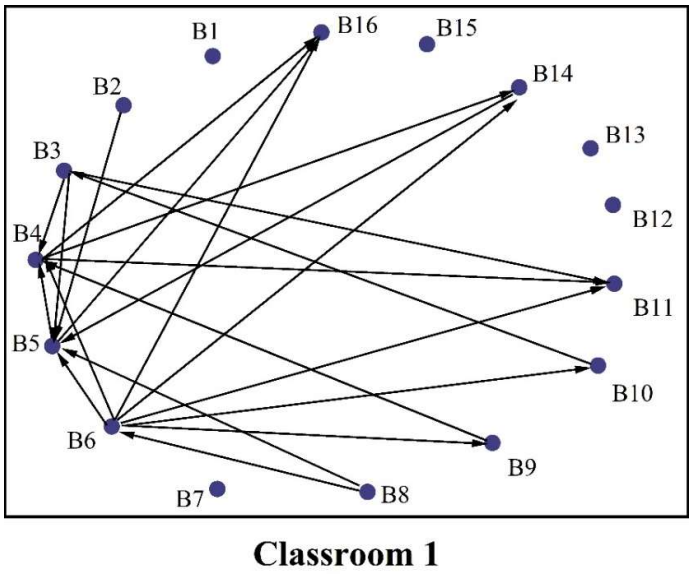

Fig. 3. Classroom 1 teaching interactive behavior network build results

The results of the network construction of teaching interaction behaviors in Classroom 2 are shown in Figure 4. In the community graph, the significant teaching behaviors are concentrated in B4, B5, B6, B9 and B10, which are located in the core of the social network of this community graph, indicating that throughout the physical education teaching, the teacher mainly focuses on asking questions, explaining and giving instructions or directions, and emphasizing the content of the teaching, and the student mainly focuses on the passive answers, but the interaction frequency is high. All other behaviors were at the edge of the network, indicating that the teacher did not focus on the use of these behaviors in teaching. In summary, this lesson had fewer opportunities for students to practice and manipulate, but the level of interaction between students and teacher was high.

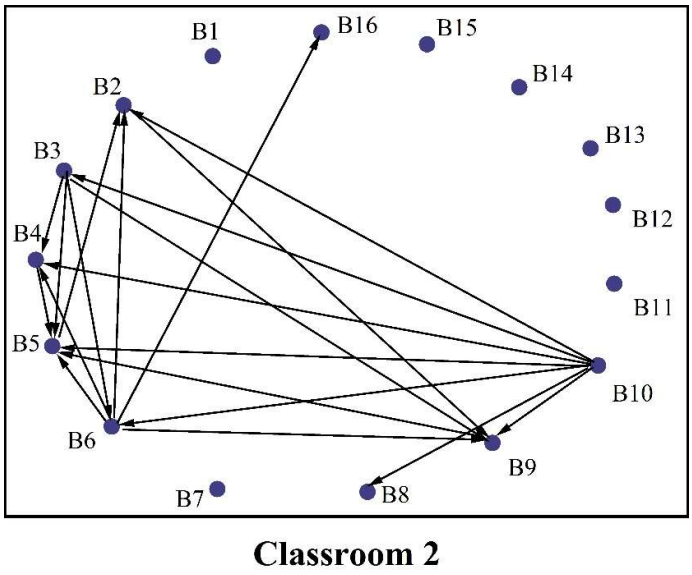

Fig. 4. Classroom 2 teaching interactive behavior network build results

The results of the network construction of teaching interaction behaviors in Classroom 3 are shown in Figure 5. In the community network construction of Physical Education Classroom 3, the physical education teaching interaction behaviors are significantly concentrated in B2~B6, in addition to the interaction behaviors of B10, B11, and B13, which are also reflected to a certain extent. This means that classroom 3 is richer than the first two classrooms in terms of teaching interaction behavior, the teacher asks questions, explains and gives guidance or instructions, emphasizes the content of the teaching at the same time has more attention to the students' teaching interactions, can provide students with certain opportunities for speech and demonstration, and the teacher is good at encouraging the students and giving them praise.

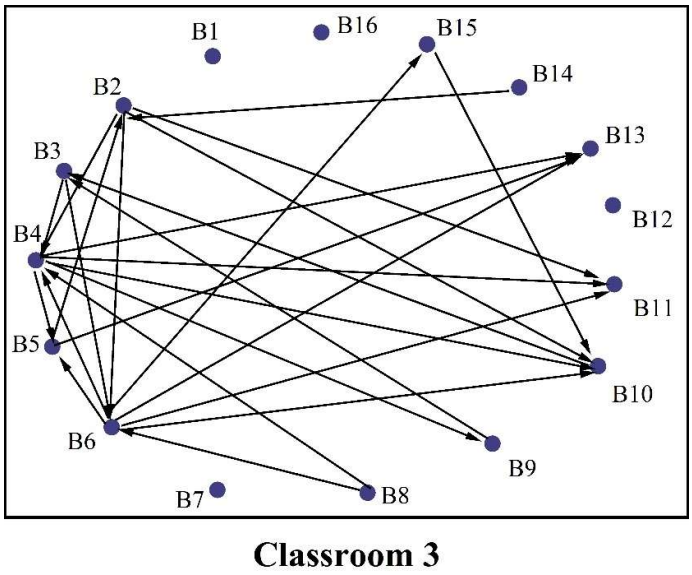

Fig. 5. Classroom 3 teaching interactive behavior network build results

The results of the construction of the teaching interactive behavior network of classroom 4 are shown in Figure 6, in the social network of physical education classroom 4, the significant interactive behaviors of physical education teaching are concentrated in B2, B4, B5, B6, in addition, B9~B11 and other interactive behaviors also have a certain embodiment, which shows that in the whole physical

education classroom teaching, the teacher's teaching interaction mainly focuses on explaining and asking questions, and students have the opportunity to use resources and take the initiative to speak, but they also have a certain silence.

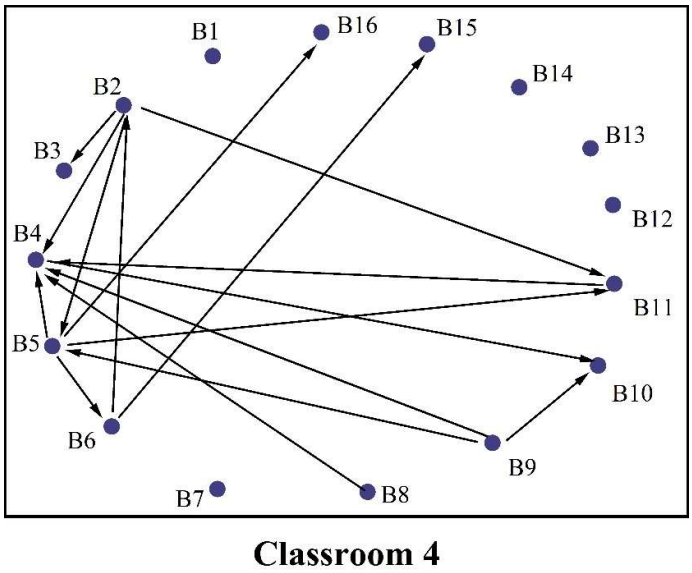

Fig. 6. Classroom 4 teaching interactive behavior network build results

3.3. Degree centrality analysis of social networks

Degree of centrality describes the learner's position and rights in the interaction group, and can reflect the degree of participation and learning commitment of individuals involved in interactive behaviors in physical education course learning. Degree is the degree of centrality of each point in the network. The degree of centrality of a point in an interaction network is measured by the number of points adjacent to that point. In a directed graph, the degree of a point consists of the in-degree and out-degree of the point, and the degree centrality of the point is equal to the sum of the in-degree and out-degree. The higher the point in-degree, the more attention the participant receives. The higher the point out degree, the more active the participant is in the social network and can actively participate in the teaching interaction behavior.

In this section, the degree centrality of a total of 69 students in four physical education courses will be analyzed, and the results of the degree centrality analysis are shown in Table 1. In the PE teaching interaction network of this study, the point-in degree is the total number of students performing teaching interactions, while the point-out degree is the total number of students responding to teaching interactions. Through, the matrix relationship data can be calculated the point-in degree and point-out degree of students participating in physical education teaching interactions, which can be seen according to the results of the degree-centeredness analysis:

1) The largest member of the point-in degree is No. 60, which indicates that student No. 60 has the highest level of attention and the most frequent physical education teaching interaction behaviors in the physical education teaching course. It shows that this student is able to initiate some topics that attract learners to discuss together, and at the same time, he/she actively participates in the physical education interaction.

2) The largest member of the point out is student No. 51, which indicates that he is very active in the physical education teaching interaction behavior in the physical education teaching course, actively participate in the teaching interaction, and at the same time, the communication with other students is also stronger, and the problem solving ability is stronger.

3) The point degree center degree indicates the total number of times an individual learner interacts in the social network, reflecting the learner's interactive participation. It is worth noting that, overall,

there are a large number of marginal learners with the number of interactions less than or equal to 2 in the physical education teaching interaction, about 33, accounting for 47% of the total number of learners in the class. It suggests that more attention should be added to marginal learners in the study of physical education teaching interactions in this paper to improve the behavior of teaching interactions on multiple aspects of students.

Table 1. Degree of degree analysis

Student ID	Point of point	Point of entry	Point center	Student number	Point of point	Point of entry	Point center
60	1	25	25	49	2	3	4
22	7	7	13	30	3	1	3
3	4	10	13	43	2	2	3
52	3	11	13	36	2	2	3
51	9	3	11	33	2	2	3
68	6	5	10	46	2	2	3
55	5	6	10	65	2	2	3
23	8	2	9	50	2	2	3
53	7	3	9	34	2	2	3
13	7	3	9	47	1	3	3
16	5	5	9	7	1	3	3
29	4	6	9	24	2	1	2
17	4	5	8	63	2	1	2
45	7	1	7	57	2	1	2
42	6	2	7	58	2	1	2
11	2	6	7	26	2	1	2
25	4	3	6	27	2	1	2
8	4	3	6	61	2	1	2
44	3	4	6	5	2	1	2
38	2	5	6	15	2	1	2
41	4	2	5	39	2	1	2
28	3	3	5	20	1	2	2
56	3	3	5	4	1	2	2
69	3	3	5	9	1	2	2
10	4	1	4	18	1	2	2
32	4	1	4	12	1	2	2
37	4	1	4	64	1	2	2
62	4	1	4	14	1	2	2
35	3	2	4	21	1	1	1
40	3	2	4	6	1	1	1
19	3	2	4	2	1	1	1
66	3	2	4	54	1	1	1
59	3	2	4	67	1	1	1
48	2	3	4	1	1	1	1
31	2	3	4				

4. Conclusion

In this paper, the research on physical education teaching interaction was launched through social

network analysis combined with physical education teaching examples. In this paper, through the four physical education teaching course examples, we obtained the physical education teaching interaction behavior data and constructed the physical education teaching interaction behavior network, and the results of the research and analysis showed that the physical education teaching interaction behavior in the social network was relatively close. The teaching interaction behavior of physical education classroom 1 is concentrated in B3, B4, B5 and B6, and the teaching interaction behavior of classroom 2 is significantly concentrated in B4, B5, B6, B9 and B10.The interaction behavior of classroom 3 and classroom 4 are basically also concentrated in B3~B6.In addition, the overall view of the physical education teaching interaction network of the degree of the degree of centrality of the physical education teaching interactive behaviors of the fringe learners, there are about 33, accounting for the study of the 47% of the total number of people. This study builds the sports interaction behavior network, from the perspective of sports interaction behavior, using social network analysis method to analyze the overall network structure of sports teaching interaction behavior and the degree of centrality, to understand the interaction mode of learning sports teaching behavior, through the analysis of the teaching interaction behavior data network, to further understand the situation of sports teaching interactions, and to find out the problems that exist in the interactive teaching of the sports teaching curriculum. It can provide a basis for improving teaching interaction in physical education.

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