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Analysis of Teacher–Student Interaction in the High School IT Class with IT-based Interaction Analysis System

Congjing Mu,[1†] Fengying Li,[2†] Shih-Pang Tseng,[3,4*] and Qingshui Xue[5**]

[1]School of Education, Shanghai Jiaotong University, Shanghai 200240, China
[2]Lifelong Education College, Shanghai Jiaotong University, Shanghai 200052, China
[3]School of Software and Big Data, Changzhou College of Information Technology, Changzhou 213164, China
[4]School of Information Science and Technology, Sanda University, Shanghai 201209, China
[5]School of Computer Science and Information Engineering, Shanghai Institute of Technology, Shanghai 201418, China

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Sensors and sensor technology have been applied in various fields such as the medical and agricultural industries. However, in the field of education, there is a scarcity of research on the use of sensor technology to analyze the teacher–student interaction process, a key factor affecting classroom efficiency. In particular, research focusing on IT classes is even scarcer. In this study, we investigate the overall status and characteristics of teacher–student interaction in the IT class using ministerial-level excellence courses. By a qualitative method, we adopt the Information-technology-based Interaction Analysis System (ITIAS) to encode the interaction behavior and use lag sequential analysis (LSA) to understand the conversion modes of interaction behavior. In addition, we analyze the participation elements, expressions, and transitions of interaction behavior. We found a trend of three-subject interaction among teachers, students, and technology. However, there exist some problems, such as technology being in the subordinate position of interaction, the lack of deep interaction between teachers and students with technology, and teachers dominating the conversion of interaction. Accordingly, we propose countermeasures for teachers and provide new ideas for the application of sensors on the interaction in the learning environment as well.

1. Introduction

In recent years, the widespread use of IT in the world has given a strong impetus to the development of modern sensor technology and its applications. Within the education informatization, using sensor technology in the teaching environment can assist teachers in understanding the status of class interaction.(1) With continuous research on big data and learning analytics, the data analysis of instructional behavior in class has become a hot spot of class study. The emergence of various learning analytic techniques related to sensor technology

*Corresponding author: e-mail: tsengshihpang@czcit.edu.cn
**Corresponding author: e-mail: xue-qsh@sit.edu.cn
†Congjing Mu and Fengying Li are the co-first authors.
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has promoted the transformation of learning methods and instructional modes in class.[2] In China, the General High School Curriculum Standard in Information Technology Area sets the goal of the IT curriculum in high school to enhance students' information literacy, emphasizing that students should participate in the communication, sharing, cooperation, and negotiation supported by IT.[3]

Interaction is a necessary condition for class instruction. Likewise, successful instruction necessarily involves the successful management of class interaction.[4] Currently, most scholars focus on the methods of interaction analysis in which sensor technology can play a big role.[5] On the basis of a large number of experimental results, teacher–student interaction in the classroom can be classified into three types: teacher-centered, student-centered, and knowledge-centered, according to the subject of interaction.[6]

In the quantitative analysis of teacher–student interaction in class, the Flanders Interaction Analysis System (FIAS) proposed by Flanders is extensively recognized.[7] FIAS takes verbal behavior as the main element of analysis and consists of a coding system to describe interaction behavior, a prescribed criterion to observe and record the codes, and an interaction analysis matrix for displaying data and conducting analysis, which classifies the verbal behavior of teacher–student interaction in class into ten categories and gives the operational definitions.

Because the coding system of FIAS is rather general and does not consider the technology factor, with the gradual spread of IT in class, the Information-technology-based Interaction Analysis System (ITIAS) was created. On the basis of FIAS, ITIAS expanded the original ten codes into 18 codes according to the characteristics of the information-based instructional environment, refined the "Teacher Talk" categories, added students' active questioning and discussion with peers in class, and quantified the interaction behavior carried out by teachers and students in class more accurately. Figure 1 demonstrates the process of analyzing the teacher–student interaction with ITIAS. ITIAS creates a correlation between the original coding system of FIAS and the IT-integrated class by adding the category of technology, which reflects the importance of technology in the interaction and is more applicable to the current IT class in China.

It is easy to see that in the high school IT class, teachers should take the learning and application of IT knowledge as the basis, guide students to participate in interaction actively, and use technology reasonably to help students obtain a high-quality learning experience.[8] However, at present, teachers often fail to interact deeply with students in class and only conduct shallow and short teacher–student interactions on "Questions and Answers". At the same time, with the high level of IT development, some educators still doubt the richness of technology in the IT class and only regard it as a teaching tool.[9] In some of the excellent IT courses, it is found that both teachers and students interact with technology at different levels in the class. On the basis of this, we use the ITIAS coding system and Lag Sequential Analysis (LSA), which is used to analyze the likelihood of the emergence of the behavior after its concomitant behavior occurs and to determine whether the sequence of a priori behavior and concomitant behavior generated is statistically significant,[10] to analyze the teacher–student interaction behavior of ministerial-level excellence courses. We propose the following two research questions:

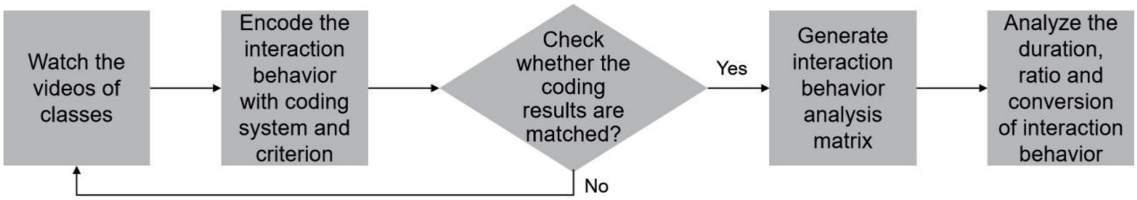

Fig. 1. Process of teacher–student interaction analysis based on ITIAS.

(1) What is the overall status of teacher–student interaction in the Chinese high school IT class?
(2) What characteristics do teacher–student interaction present in different course types from the technology perspective?

2. Methodology

2.1 Sample

The sample was drawn from the 2019 "one division, one excellent class, one course, and one teacher" activity,[11] in which the ministerial-level excellence courses of IT subjects in high school were selected. The ministerial-level excellence courses, as the best representative of various excellence courses, can better reflect the instruction level and technology application ability of teachers and the problems that may commonly exist in other classes. Among the excellence courses using the 2003 textbook version, 15 ministerial-level excellence courses were offered. According to the properties of the teaching contents, the 15 courses were divided into three types: theoretical, skill, and experimental courses, including nine theoretical courses, which mainly included theoretical knowledge of algorithms, selection structures, and branch structures; 5 skill courses, which mainly included database information retrieval, table data processing, and other operations; and one experimental course, which required students to work in groups to build a wireless local area network (WLAN) with appropriate tools. Therefore, we selected seven courses covering all three types as research samples (as shown in Table 1). These courses have clear audio and video recordings, complete and feasible instructional design, and targeted teaching resources, which are suitable for the analysis.

2.2 Data collection and analysis

The coding rules of the analysis system used in this study are approximately the same as those of ITIAS, with corresponding adjustments made to the number of codes, rules, and content in the ITIAS coding system (as shown in Table 2).

However, the analysis results obtained through ITIAS only indicate the number of occurrences of interaction behavior and the frequency of conversion. They cannot determine whether the conversions of particular behavior need to be taken seriously, which is not conducive to understanding the depth of teacher–student interaction in class and the role of technology in

Table 1
Basic information of seven courses.

No.	Title	Type
Case 1	DIY – Branch Structure Theme	Theoretical course
Case 2	Appreciation and Production of Microfilm	
Case 3	Computer's Network Identity – IP Address	
Case 4	Diversity in the Processing of Tabular Data	Skill course
Case 5	Understanding Dynamic HTML – CSS Style Sheets	
Case 6	Raspberry Pi Smart Car	
Case 7	Build Small Area Network – WLAN	Experimental course

the interaction.[12] Because of the diverse and distinct connotations associated with various interaction behaviors, we chose to use qualitative methods for data collection and analysis. First, we adopted the adapted coding system (as shown in Table 2) to analyze teacher–student interactions. On the basis of coding rules, it coded and recorded the interaction behavior in the selected course cases. The primary interaction behavior was recorded every 6 s during the coding process. There were two coders for the samples simultaneously to ensure the reliability of the coding. At the beginning of the coding, the two coders were thoroughly familiar with the coding tool used in this study and formed a more unified perception of the connotation of each category code through communication; then, they coded the same course, compared the coding results, and discussed and agreed on the differences; finally, the two coders independently conducted the formal coding of the samples to obtain the final behavioral codes. On the basis of the behavioral codes agreed upon by the two coders, LSA was conducted using the interaction behavior analysis software GSEQ to generate an interaction behavior conversion frequency table and display the adjusted residuals.[13] Among them, the table shows the frequency of occurrence of concomitant behaviors and the behavior sequence is statistically significant when the adjusted residual value is more than 1.96.[14] Finally, we analyzed the sequences of interaction behavior and their significance, converting the coding results and behavioral sequences into visual charts to understand the overall status and characteristics of teacher–student interaction in the high school IT class.

3. Results

3.1 Overall status of teacher–student interaction in the high school IT class

3.1.1 Influence of "Teacher Talk"

"Teacher Talk" in the class included both direct and indirect influences. The direct influence was mainly in the form of lecturing, giving directions, and justifying authority, the latter two types of which had a negative reinforcing effect on students. On the other hand, the indirect influence was mainly in the form of asking questions and praising, encouraging, and accepting the ideas of students, both of which reinforced students positively. As can be seen from the data in Table 3, the ratios of hours of indirect to direct influence and positive to negative reinforcement

Table 2
Coding system for analysis of teacher–student interaction in the high school IT class.

Area		Code	Type	Type of ITIAS	Content
Teacher Talk	Indirect Influence	T1	Encourages praises and accepts the ideas of students	Accepts feelings	Praising or encouraging students' action or behavior; acknowledging their statement; modifying or restating and applying it to solve the problem; comparing it with other statements; summarizing their ideas.
				Praises and encourages	
				Accepts ideas of students	
		T2	Asks open–ended questions	Asks open-ended questions	Asking questions with open–ended, non–standard answers based on the teacher's input and content, expecting divergent responses.
		T3	Asks closed questions	Asks closed questions	Asking closed, fixed-answer questions based on the teacher's input and content, expecting standard answers.
	Direct Influence	T4	Justifies authority	Criticizes	Maintaining their own trust and compliance during the teaching process and attempting to correct students' performance in class.
		T5	Lectures	Lectures	Providing facts or insights about the content, presenting the teacher's own ideas and interpretations, or quoting someone in authority (not students).
		T6	Gives directions	Gives directions	Instructing or ordering students to do something and expecting them to accept or obey.
Student Talk		S1	Responds passively	Response (passive)	Answering questions posed by the teacher. Teachers assign students to answer or guide them to answer questions where students are limited in freely expressing their ideas.
		S2	Responds actively	Response (active)	Going beyond the answer to the question and expressing their own ideas; sparking new topics; expressing insights and ideas freely, e.g., proposing open–ended structures.
		S3	Asks questions actively	Asks questions actively	Asking questions on their own initiative.
		S4	Discusses with peers	Discusses with peers	Discussing and exchanging ideas with peers to help each other in response to the issues presented.
Confusion and Silence		C1	Useless confusion for teaching	Useless confusion for teaching	Teachers temporarily stop lecturing, and a short period of disruption in class with no effective communication between teachers and students.
		C2	Useful silence for teaching	Ponders	Pondering over questions; completing exercises on textbooks or other paper materials.
				Exercises	
Technology Application		TT	Teachers manipulate technology and students observe	Teachers manipulate technology	Teachers use technology to demonstrate instructional content and illustrate ideas while students observe media presentations and complete exercises on the screen.
				Technology acts on students	
		ST	Students manipulate technology	Students manipulate technology	Students use technology to present learning outcomes or group work and illustrate ideas; students complete online exercises in class.

Table 3
Statistics on the influence and reinforcement of "Teacher Talk".

Teacher Talk	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Ratio of hours of indirect to direct influence (%)	24	20	50	94	45	21	28
Ratio of hours of positive to negative reinforcement (%)	41	133	73	233	94	63	30

in most of the classes are less than 1, reflecting teachers' tendency to control the class directly and force students to accept or obey by negative reinforcement.

In addition, to analyze teachers' tendency to use language in classroom interactions, the frequency and proportion of teachers' questioning were counted, and it was found that among all teachers' verbal behaviors, the proportion of time spent on asking questions was small, mostly around 15%, with a maximum of 35%. Furthermore, according to the video recordings in class, it was found that although teachers asked closed questions predominantly, the frequency of asking open-ended questions was equal to that of asking closed questions in many cases, and even in some cases, teachers mainly asked open questions.

3.1.2 "Student Talk" and "Silence"

We take Case 1 "DIY – Branch Structure Theme" as an example (timeline data can be seen in Fig. 2). Students rarely talked in the early part of the class, but in the middle and later parts of the class, there was a notable increase in students' verbal behavior. Therefore, students took a long time to enter the class but enjoyed participating in the interaction for a long time after their interest in learning had been piqued.[15] We classified students' active verbal behavior, which could reflect their initiative in participating in the interaction,[16] into two categories: responding actively and asking questions actively. Among students' verbal behaviors, passive talking accounted for a larger proportion than active talking, with around 10% and a maximum of 25% of all students' verbal behaviors. On the other hand, active verbal behavior was mainly manifested as active responses, and students rarely asked questions actively in class. According to the records in class, students were also less likely to discuss with their peers spontaneously if not instructed by the teacher.

In these cases, the proportion of confusion was minimal and occurred when students had just completed technical operations or finished group discussions. Silence accounted for about 10% of the interaction in class as a whole, with a maximum of 27%. In addition, there was "ineffective interaction" during the class, mainly when students were operating the computer, and the teacher walked around without interacting with them individually or in small groups and hovered around the podium occasionally.

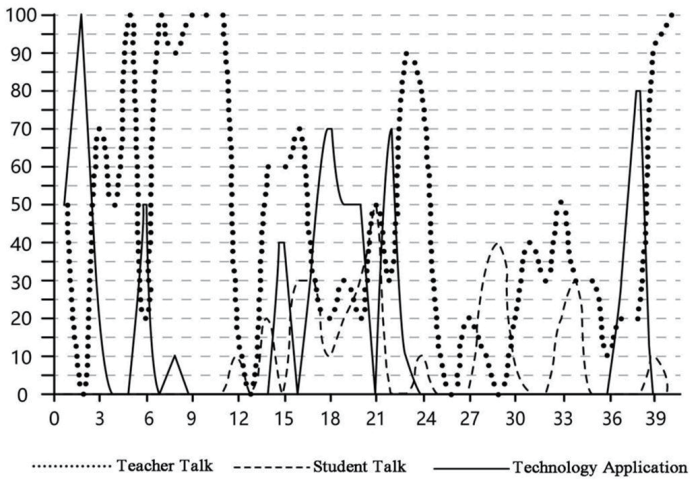

Fig. 2. Timeline of Case 1.

3.2 Characteristics of teacher–student interaction in the high school IT class

3.2.1 Participation elements of interaction in class

In the IT class, which is conducted in the technology environment, technology plays both the roles of instructional content and participation elements in the interaction, accounting for about 20% of the course duration (as shown in Fig. 3), showing a three-subject interaction among teachers, students, and technology.

On the basis of the observation of records in class, it was found that in the theoretical courses, most of the interaction behavior occurred between the teacher and students, except for the short two-way interaction between the teacher and the technology during the phase of new knowledge instruction, where students had little access to the technology, while in the skill courses, the teacher, students, and technology interacted with each other. For a portion of the class duration, the teacher led the classroom interaction with vocal delivery, supplemented by technical tools to instruct the operation steps, and students observed the demonstration. During other times in class, students' leading role in the interaction was highlighted when they simultaneously interacted with their peers and technology to complete the tasks. Likewise, in the experimental courses, the teacher used technology in class to create the learning environment and present the content consciously, and then gave students the ownership of interaction so they had ample time to interact with technology.

3.2.2 Manifestation of interaction behavior

In the theoretical courses, it was found that the types of interaction between the teacher and technology in Case 1 were diverse. The interaction included showing multimedia courseware, showing samples of programs, distributing learning materials, and assessing homework, among

Fig. 3. Ratio of hours of technology application to the whole class.

which the level of interaction in showing samples of programs was the deepest. When the teacher ran the program, the program would output the result. In this way, the teacher created learning situations for students with the performance of the technology.[17] On the other hand, the interaction between the students and technology was mainly in the form of writing and running the program and submitting assignments, where students acted on the program and got real-time feedback to test their learning outcomes.[18] Cases 2 and 3 were both carried out in traditional classrooms. The teacher interacted with the technology mainly by showing multimedia courseware and demonstrating exercises. The teacher also interacted with the technology at a deeper level through operations. In comparison, the students only observed or worked in groups to complete the exercises and had fewer opportunities to interact with the technology at a deeper level.

The three skill courses selected were conducted in the computer room. In Case 4, the interaction between the teacher and technology was mainly manifested by showing the multimedia courseware and demonstrating the operation steps. In the demonstration process, the teacher frequently interacted with the technology, showing the instructional content to the students through the feedback of the technology. In addition, the interaction between the students and technology was more diverse, including sharing the computer screen to report the learning results. Since the students used technology just as a tool to show their results, the level of interaction was shallow. In Case 5, the interaction between the teacher and technology was mainly in the form of showing the multimedia courseware and demonstrating the operation steps, whereas the interaction between the students and technology was completing exercises and submitting assignments superficially. Regarding Case 6, the teacher showed the multimedia courseware with the help of technology. At the same time, the students dealt with technology by writing and running programs. However, the programming process was mainly carried out under the teacher's guidance and the help of classmates, leading to a shallow interaction with the technology as well.

The experimental course case was carried out in the computer room. The interaction between the teacher and technology was mainly to present multimedia courseware with the help of technology, including playing prerecorded microlectures, which were more diverse but shallow. The interaction between the students and technology was characterized by setting up WLAN and completing exercises on the computer. Students explored instructional content in groups according to technology feedback, which was on a deeper level than submitting online assignments.

3.2.3 Conversion of interaction behavior

In GSEQ software, the behavioral data obtained after course coding was imported, generating a transfer matrix and combining the adjusted residual values to explore the conversion of interaction behavior in different course types from the technical dimension. The course "DIY – Branch Structure Theme" was an example of a theoretical course. First, the teacher showed the sample program on a computer. Then, the teacher transferred the learning materials to the students' computers and instructed them to practice and imitate the operation on the computer. When most students finished the operation, the teacher sent instructions about the next instructional activity, using oral language to promote the process. It was found (as shown in Table 4) that the proportion of teachers manipulating technology (TT) is much lower than its verbal behavior (T1–T6), and the teacher mostly switched to lecturing (T5) and giving directions (T6) after interacting with the technology. Students also switched to the teacher's lecture (T5) after completing their interaction with technology (ST), with the summary by the teacher at the end.

Unlike theoretical courses, there are more opportunities for teachers and students to interact with technology in skills courses. Taking the skills course "Understanding Dynamic HTML – CSS Style Sheets" as an example, based on the statistics of its interaction behavior conversion data (as shown in Table 5) and the observations of the records in class, it was found that the

Table 4
Interaction behavior conversion frequency of Case 1.

Z	T1	T2	T3	T4	T5	T6	S1	S2	S3	S4	C1	C2	ST	TT
T1	7	2	2	0	4	1	0	0	0	0	0	2	0	0
T2	0	2	0	0	3	0	1	0	0	0	0	0	0	0
T3	0	0	4	0	3	0	5	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T5	4	0	6	0	73	4	2	2	0	1	0	4	7	0
T6	0	1	0	0	4	28	0	0	0	0	0	8	1	1
S1	3	0	0	0	3	1	11	0	0	0	0	0	1	0
S2	1	0	0	0	1	1	0	1	1	0	0	0	0	0
S3	0	0	0	0	4	0	0	0	2	0	0	0	0	0
S4	0	0	0	0	0	0	0	0	0	6	0	2	0	0
C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	2	0	0	0	2	7	0	1	3	1	0	95	0	0
ST	0	1	0	0	6	1	0	1	0	0	0	0	48	0
TT	1	0	0	0	0	0	0	0	0	0	0	0	0	10

Table 5
Interaction behavior conversion data statistics of Case 5.

Interaction behavior	Teacher Talk	Student Talk	Teachers manipulate technology and students observe	Students manipulate technology
Teacher Talk	167	18	11	6
Student Talk	15	84	0	0
Teachers manipulate technology and students observe	10	0	30	0
Students manipulate technology	5	1	0	75

Note: The leftmost column represents the initiating behavior; the topmost row represents the accompanying behavior. For example, the number "15" indicates that the "Teacher Talk" behavior follows 15 times the "Student Talk" behavior in class.

teacher took the lead in demonstrating the skills and provided students with opportunities to interact with the technology after explaining the tasks. When students completed their interactions with the technology, the teacher evaluated their performance and outcomes, then moved on to other tasks.

Experimental courses require the teacher to guide the students in applying the relevant technology to produce results. Therefore, the teacher turned to verbal behavior in the class after interacting with the technology and interspersed language with technology to create learning situations and facilitate students' interaction. After interacting with the technology, students often turned to discussions with peers or active questioning.

4. Discussion

4.1 Analysis of the overall status of teacher–student interaction in the high school IT class

On the basis of the coding results of the seven courses, "Teacher Talk, Student Talk, Confusion and Silence, and Technology Application" dimensions occupy different proportions of the class duration. Generally, this shows the state of "Teacher Talk > Student Talk > Technology Application > Technology Application". Teachers are more adept at influencing students' learning process using lectures, instructions, and negative reinforcement to force them to accept knowledge.[19] When students make mistakes, teachers' feedback, such as guiding students to think about the reasons for their errors or correcting their answers, is more likely to promote their enthusiasm for learning. Although the frequency of teachers' questions is low, they focus on the quality of questions and ask open-ended questions closely related to the instructional content to cultivate students' divergent thinking.[20] At the same time, analyzing the time distribution of students' verbal behavior in class is helpful in inferring the level of students' participation and motivation in the interactions.[21] The proportion of students' verbal behavior is relatively high, but it takes a long time for them to engage in the interactive state. In the interaction, students answer questions raised by teachers passively, with a lower proportion

of active expression of ideas or questions. Analyzing the proportion of confusion and silence in classroom interactions helps to understand the effective instructional time for the whole class.[22] Confusion is rare, with occasional short periods of confusion during switching instructional activities. In contrast, silence occurs more and is mainly manifested as the deliberate arrangement by teachers. In addition, the proportion of technology application in classroom interaction is high, but the level is shallow.

In general, the current interaction in the high school IT class is still challenging to escape the dilemma of being teacher-centered. Teachers' interaction style is still indoctrination, although there is a transition trend to inspiration. Students' participation in interaction is high, but they still need to show more initiative in interacting with teachers and exploring the use of technology. The proportion and level of technology application are generally low. Under this circumstance, teachers need help with their methods of participating in interaction.[23]

4.2 Analysis of the characteristics of teacher–student interaction in the high school IT class

Teachers, students, and instructional content are three essential elements that constitute the teaching activities. In regular classes, interaction is generally manifested as double-subject interaction between teachers and students, and they have an equal relationship.[24]

Most of the IT theoretical courses are conducted in ordinary classrooms, which presents the situation of teachers showing multimedia courseware and students watching the courseware for a long time. Therefore, the interaction only occurs between teachers and students. In this way, teachers and students are the main participation elements of interaction and jointly occupy the primary position of interaction in class. The interactive status of technology needs to be improved and addressed. Unlike theoretical courses, skill courses are mostly conducted in the computer room, and both teachers and students can interact with technology. Therefore, teachers and students dominate the classroom interaction in the skill courses. The technology is used throughout the whole class with a low but stable proportion of interaction, reflecting that although the interactive status of technology is less important than that of teachers and students, it has been valued as a participation element of interaction in class. As for the experimental courses, the interaction elements are represented by teachers, students, and technology, but their interactive status is unequal. Teachers and students are in dominant positions, whereas technology, only cooperating with teachers or students for a time, is in a subordinate position. It can be concluded that the high school IT class presents a three-subject interaction between teachers, students, and technology. However, technology is in a subordinate position compared with the two traditional interactive elements. The interaction behavior mainly occurs between teachers and students using language as the carrier, and technology is only used as an auxiliary tool to cooperate with the verbal behavior of teachers and students. Therefore, the role of technology as an interactive participant needs to be reexamined.

In a three-subject interactive IT class, technology demonstrates different instructional contents and serves different learning objectives. It is mainly divided into three categories: teacher–student interaction, teacher–technology interaction, and student–technology interaction.

The depth of interaction varies in different instructional contents.[25] For theoretical courses, compared with courses in the ordinary classroom, teachers and students can interact with technology in richer forms and at deeper levels in the computer room. Owing to the nature of the skill courses, there are more opportunities and various forms of interaction with technology. Both teachers and students interact with technology at a deeper level several times, but the overall level is generally shallow. At the same time, teachers often need to pay more attention to students' prior knowledge and experience when demonstrating the operations in case of limiting students' thinking processes. Unlike the above two course types, in the experimental courses, the interaction behavior presents a situation where teacher–technology interactions are neck and neck with student–technology interactions. On the other hand, the manifestation of interaction behavior in the experimental courses closely relates to the instructional design. The interaction behavior within teachers, students, and technology designed by different teachers may differ for the same instructional content. A more profound interaction behavior only takes up a small proportion of class duration and fails to attract teachers' attention. The interaction behavior between students and technology mainly remains in the learning declarative knowledge of IT subjects through technology. In general, although the manifestations of interaction behavior are rich, they are primarily shallow, and teachers and students lack deep interactions with technology.

Multi-directional interaction in class should be circular and recursive, advancing dynamically among subjects of interaction to keep them interacting continuously. The conversion of interaction behavior affects the status of each participation element in the interaction.[26] From the analysis results, it can be seen that the conversion mode of interaction behavior in the theoretical courses is relatively simple, primarily manifested in the teacher's verbal behavior. Although this conversion mode is conducive for teachers to grasp the class rhythm, it tends to deprive students of the opportunity to interact with technology in greater depth. In skill courses, the proportion of students manipulating technology is high. When students finish manipulating technology, it is mainly converted to teachers' verbal behavior, such as lecturing and justifying authority. In skill courses, teachers are accustomed to using language to explain the tasks of inquiry to students, expecting them to master skills through their own effort in the interaction with technology. However, the evaluation of the results is still dominated by teachers, who fail to use technology to release the tasks and evaluate them, leading to insufficient interaction with technology. As for the experimental courses, although the conversion of interaction behavior tends to be "student-centered" and creates opportunities for students to interact with technology fully, it still cannot get rid of teachers' control over the class.

In summary, teachers and students mainly convert to teachers' verbal behavior after interacting with technology. This shows that teachers still play a dominant role in the conversion of interaction behavior, ignoring the role of technology as a link between the conversion of each interaction behavior and as a connection between teachers and students. As a result, teachers neither provide students with the opportunity to fully interact with technology nor can they fully interact with the technology themselves. In this way, although the class rhythm can be strictly controlled, the advantages of the technological environment cannot be maximized, and the creation of the IT learning environment and the effectiveness of students' learning will be affected.

5. Conclusions and Suggestions

5.1 Conclusions

In this study, we utilized sensor technology to explore teacher–student interaction behavior within the learning environment creatively. As a hot issue in IT teaching and learning research, teacher–student interaction in class has attracted the attention of educators at all levels. Thus, we explored the overall status of different types of teacher–student interaction behavior, including "Teacher Talk, Student Talk, Confusion and Silence, and Technology Application" in the high school IT class with the help of ITIAS. Furthermore, we focused on the unique role of technology in the interaction and used LSA to explore the conversion of interaction behavior. The results of this study may help improve the effectiveness of interaction in class with the support of technology to teach IT knowledge and application and provide innovative ideas to maintain students' enthusiasm to interact with various subjects in the IT class.

5.2 Suggestions

On the basis of the results of data analysis, the following strategies are proposed to optimize the teacher–student interaction behavior in the high school IT class: first, attach importance to the interaction status of technology and guide students to participate actively. Teachers should update the concept of interaction in class and enhance their initiative in technology application.[27] IT teachers should pay attention to the interaction status of technology, think about ways to make technology participate in the interaction of IT class equally, impart IT knowledge via technology, and improve students' ability to learn, collaborate, and express themselves by technology.

Second, enrich the manifestation of technology application and attract students to interact deeply. IT teachers should make full use of technological conditions, enrich the manifestation of technology in the interaction, and conceive forms of technology applications that can help teachers, students, and technology carry out deep interaction.[28] At the same time, teachers can appropriately improve the technology utilization rate in the interaction of IT classes. Teachers should arrange the instructional activity with moderate duration for students to interact with technology in each class. Abusing technology in the interaction tends to interrupt students' process of thinking and constructing the knowledge system of IT and is not conducive to the deep interaction between students and technology.

Finally, exert the role of technology as a tie and maintain the enthusiasm of students for the interaction. According to the characteristics of the interaction behavior, the various interaction behaviors in the IT class are mostly converted by teachers' verbal and blunt behavior. Therefore, teachers should improve their skills in instructional design to make techonology as a bond. First, teachers can use various technologies combined with their own verbal behavior to create learning situations and ask inquiry questions through technology. Second, on the basis of the difference in instructional content, technology can be applied to link up different teaching sessions, giving students multiple, real-time feedback to help them correct mistakes.[29] Third,

teachers can provide students with the opportunity to present their works so that they can share their creative ideas with their classmates and respond to the inquiry questions with technology.

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References

1 B. Schneider, J. Reilly, and I. Radu: J. STEM Educ. Res. **3** (2020) 91. https://doi.org/10.1007/s41979-020-00027-x
2 H. Cornide-Reyes, R. Noël, F. Riquelme, M. Gajardo, C. Cechinel, R. Mac Lean, C. Becerra, R. Villarroel, and R. Munoz: Sensors **19** (2019) 3291. https://doi.org/10.3390/s19153291
3 Ministry of Education of the People's Republic of China: General High School Curriculum Standard in Information Technology Area (2017 Edition 2020 Revision) (People's Education Press, Beijing, 2020) 1–5.
4 R. L. Allwright: Appl. Linguistics **5** (1984) 156. https://doi.org/10.1093/applin/5.2.156
5 Y. Lu, S. Zhang, Z. Zhang, W. Xiao, and S. Yu: Sensors **17** (2017) 1382. https://doi.org/10.3390/s17061382
6 B. J. Ashley, H. Cohen, and R. G. Slatter: An Introduction to the Sociology of Education (Macmillan, London, 1969) pp. 25–32.
7 N. Flanders: Analyzing Teacher Behavior (Addison-Wesley, MA, 1970) pp. 60–62.
8 S. E. Rimm-Kaufman, A. E. Baroody, R. A. A. Larsen, T. W. Curby, and T. Abry: J. Educ. Psychol. **107** (2015) 170. https://doi.org/10.1037/a0037252
9 V. O. Amatari: Int. J. Sec. Educ. **3** (2015) 43. https://doi.org/10.11648/j.ijsedu.20150305.11
10 I. K. Hawks: Psychol. Rep. **61** (1987) 955. https://doi.org/10.2466/pr0.1987.61.3.955
11 General Office of Ministry of Education of the People's Republic of China: http://www.moe.gov.cn/srcsite/A06/jcys_jyzb/201903/t20190311_372911.html (accessed March 2019).
12 M. Erickson, D. Marks, and E. Karcher: Teach. Learn. Inq. **8** (2020) 138. https://doi.org/10.20343/teachlearninqu.8.1.10
13 R. Bakeman and V. Quera: Analyzing Interaction: Sequential Analysis with SDIS and GSEQ (Cambridge University Press, Cambridge, 1995) pp. 38–40.
14 R. Bakeman: Observing Interaction: An Introduction to Sequential Analysis (Cambridge University Press, Cambridge, 1997) pp. 1–7.
15 N. Mercer, S. Hennessy, and P. Warwick: Int. J. Educ. Res. **97** (2019) 187. https://doi.org/10.1016/j.ijer.2017.08.007
16 N. Johnston, H. Wildy, and J. Shand: Learn. Instr. **80** (2022) 101580. https://doi.org/10.1016/j.learninstruc.2022.101580
17 M. N. Tsai, Y. F. Liao, Y. L. Chang, and H. C. Chen: Thinking. Skills Creativity **38** (2020) 100747. https://doi.org/10.1016/j.tsc.2020.100747
18 A. Gupta and D. Fisher: MIER J. Educ. Stud. Trends Pract. **1** (2011) 41. https://doi.org/10.52634/mier/2011/v1/i1/1625
19 G. J. Hwang and C. H. Chen: Br. J. Educ. Technol. **48** (2017) 950. https://doi.org/10.1111/bjet.12464
20 H. T. Hou and S. Y. Wu: Comput. Educ. **57** (2011) 1459. https://doi.org/10.1016/j.compedu.2011.02.012
21 L. Bai and Y. X. Wang: Res. Comp. Int. Educ. **17** (2021) 71. https://doi.org/10.1177/17454999211038774
22 S. Wang and M. Moskal: J. Comp. Int. Higher Educ. **11** (2019) 52. https://doi.org/10.32674/jcihe.v11iWinter.1087
23 X. Yang, J. Li, X. Guo, and X. Li: Internet Higher Educ. **25** (2015) 28. https://doi.org/10.1016/j.iheduc.2014.12.003
24 W. Lin, H. Yin, J. Han, and J. Han: Int. J. Environ. Res. Public Health. **17** (2020) 4742. https://doi.org/10.3390/ijerph17134742
25 S. Yi, R. Yun, X. Duan, and Y. Lu: J. Educ. Technol. Syst. **49** (2021) 461. https://doi.org/10.1177/0047239521988999
26 J. Batlle: Syst. **97** (2021) 102438. https://doi.org/10.1016/j.system.2020.102438

27 Y. J. Tan, C. Quek, and G. Fulmer: Asia-Pac. Educ. Res. **28** (2019) 429. https://doi.org/10.1007/s40299-019-00444-6
28 J. C. Hsiao, S. K. Chen, W. Chen, and S. S. Lin: Comput. Educ. **178** (2022) 104403. https://doi.org/10.1016/j.compedu.2021.104403
29 K. D. Vatty and S. M. Gamlem: Cambridge J. Educ. **50** (2020) 371. https://doi.org/10.1080/0305764X.2019.1707512