Exploration of the Teaching and Learning Model for College Students with Autism Based on Visual Perception—A Case Study in Nanjing Normal University of Special Education

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Abstract. Autism is a neurodevelopmental disorder with clinical diversity and heterogeneous etiology. The main clinical features are language problems, social communication disorders, and stereotyped behaviors. With the development of society and economy, more and more autistic children can study in regular classes because of early intervention, receiving common compulsory education and the rehabilitation of education intervention at this stage. It means that more and more autistic teenagers will receive higher education in the future. Therefore, it is necessary to conduct effective teaching design in the integrated classroom of higher education and propose teaching and learning models suitable for the personality characteristics of autistic college students so as to stimulate their learning interest and potentials and help them to establish self-confidence, thus encouraging them to actively participate in communication, and ensuring them to complete degree courses, which will improve the effectiveness of education intervention rehabilitation to a certain degree. This article uses the degree-based course "Linear Algebra" as an example to discuss and summarize the practice of integrated classrooms with autistic students in Nanjing Normal University of Special Education, trying to explore the teaching and learning model suitable for the personality characteristics of autistic students.

Keywords: Higher Education · Integrated Classroom · Mild Autism · MATLAB Visual Presentation · Cooperative Learning

1 Introduction

Autism is a neurodevelopmental disorder with clinical diversity and heterogeneous etiology. The main clinical features are language problems, social communication disorders, and stereotyped behaviors. According to statistics released by the US Centers for Disease Control and Prevention in 2016, the incidence of autism has reached 1 in 45, and it is showing a clear upward trend [1]. In 2006, autism, as a kind of mental disability, was included in the Second National Sampling Survey of Disability. According to the data of

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the Second National Sampling Survey of Disability in 2006, the number of children with mental disabilities was confirmed to be 145,000, 2.9% of the total number of disabled children aged 0–17, of which 41,000 were children with autism. Besides, among the 1.749 million children with intellectual disabilities and the 1.435 million children with multiple disabilities among the disabled children, there might also have autistic children [2]. However, according to the "Report on the Development Status of China's Autism Education and Rehabilitation" [3] released in April 2017, the number of people with autism in China may be more than 10 million, and the number of autistic children aged 0–14 may be more than 2 million, showing a sharp upward trend in China [4].

With the development of society and economy, more and more autistic children can study in regular classes because of early intervention, receiving common compulsory education and the rehabilitation of education intervention at this stage. It means that more and more autistic teenagers will receive higher education in the future [5–7]. Therefore, how to design a teaching program of personality characteristics suitable for college students with autism in the integrated classroom of higher education will affect the learning of degree courses of college students with autism, as well as the educational intervention and rehabilitation of college students with autism [8–10].

"Linear Algebra" covers the main content of linear equations and matrices, and is the basic academic course of special education and computer science in Nanjing Normal University of Special Education. For students who are new to Linear Algebra, it is the first time to know some concepts of Linear Algebra and many are quite abstract. Therefore, how to design a teaching program suitable for students' understanding seems to be of paramount importance [11–13]. This article uses Matlab to intuitively demonstrate some concepts of Linear Algebra to facilitate students' learning, understanding and using. Matlab can help to display some knowledge of Linear Algebra, present intuitive cognition, and stimulate students' interests in learning. At the same time, explore the cooperative learning model in the integrated classroom, conduct social intervention and rehabilitation for college students with autism, help them better integrate into the class and engage in active communication, cultivate their capability of independent learning, and improve autistic college students' passing rate of the degree course assessment [14, 15]. In Nanjing Normal University of Special Education, there are two autistic students respectively in grade 2017 and 2018 participating in the learning of Linear Algebra. Therefore, this article tries to make a case study of Linear Algebra to explore the design of teaching and learning models for integrated classrooms in higher education. The main contributions are as follows:

(1) Design of Linear Algebra teaching planning based on Matlab visual presentation to get the students' attention, specifically the student with Autism. The visual stimulation teaching planning can help them improve their understanding, and help them better understand the basic degree courses.
(2) Design of the Supervised and mutually-aided learning intervention planning can help autistic students master the knowledge of the course, guide them to lead communication, and cultivate normal students' problem-solving skills.

2 Design of Linear Algebra Teaching Planning Based on Matlab Visual Presentation

Matrix operation for a large part of Linear Algebra. The solution of many problems is finally transformed into matrix problems. Therefore, this section focuses on the Matlab-based visual presentation of three aspects, that is, the introduction of matrix concept, the calculation of matrix, and the application of matrix, to help autistic college students develop a more intuitive understanding of concepts, operations, and applications of matrix. Matrix is a table of m $\times$ n elements arranged in m rows and n columns. The element aij locates in the ith row and the jth column. For example, the table $A = \begin{bmatrix} 441 \\ 352 \\ 323 \\ 213 \\ 123 \end{bmatrix}$ is a 5 $\times$ 3 matrix. The element 5 locates in the second row and the second column of the matrix. If each row of the matrix is taken as one point, the first column is the coordinate relative to the X axis, the second column is the coordinate relative to the Y axis, and the third column is the coordinate relative to the Z axis, and the scatter plot of the three-dimensional matrix A is shown in Fig. 1.

If the matrix $B = \begin{bmatrix} 222 \\ 222 \\ 222 \\ 222 \\ 222 \end{bmatrix}$, then $A + B = \begin{bmatrix} 663 \\ 574 \\ 545 \\ 435 \\ 345 \end{bmatrix}$, that is, the elements of the corresponding positions are added together, which can be shown in the same space in the form of scatter plot in Fig. 2. Each plot is translated along the coordinate axis.

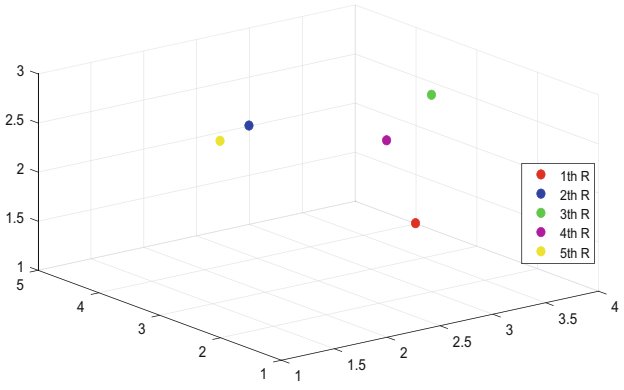

Fig. 1. Scatter plot of matrix A

The above results show a scatter plot with the rows of the matrix in the form of a vector in the three-dimensional coordinates. In fact, the pictures we usually see are also

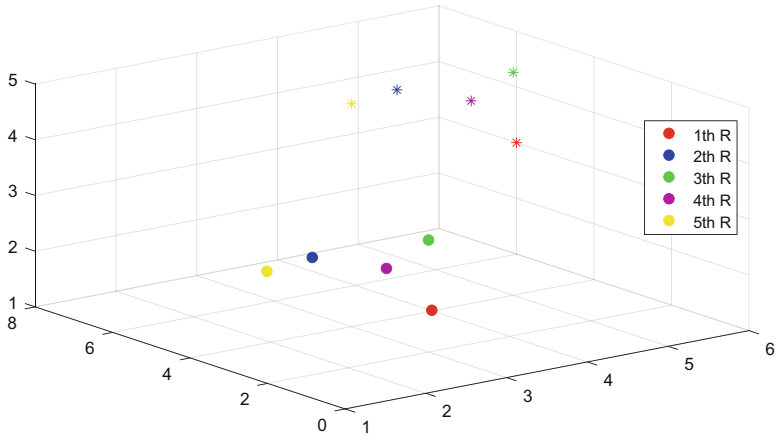

Fig. 2. Scatter plot of matrix A+B

stored in the form of a matrix, as shown in Fig. 3. From the visual effect, we can see that the image of the puppy is blurry compared to the image of the jellyfish. It indicates different matrix dimensions of images.

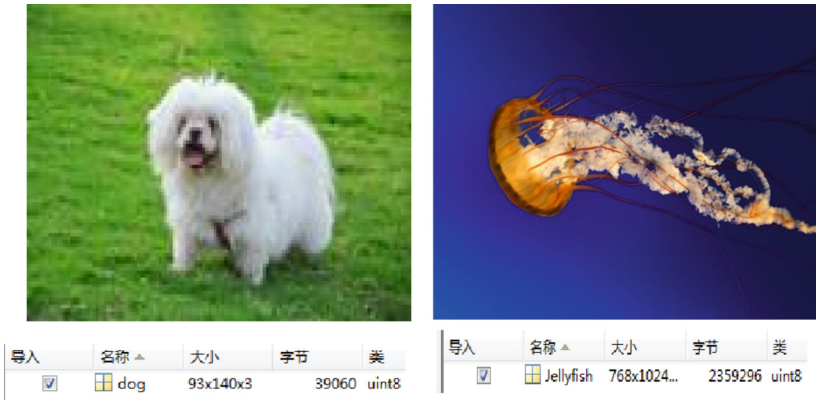

Fig. 3. The Byte Size of the Dog and Jellyfish

The gray data matrix of the puppy image is a 93 × 140 matrix, while the gray data matrix of the jellyfish image is 768 × 1024. The puppy image data matrix is much smaller than the jellyfish image. When we transform the puppy image data matrix into a matrix of the same dimension of jellyfish, it generates a new image, as shown in Fig. 4. Apply matrix addition to transform the two images and get the Fig. 5. The effect of using matrix addition to transform two images is shown in Fig. 5, and the effect of running matrix subtraction on two images is shown Fig. 6. That is to say, the application of the visualization effect facilitates the application of the parameter matrix operation to the data matrix in the integrated classroom. Autistic college students can develop a more

intuitive understanding of the concept and operation of the matrix, as well as the effect of matrix operation on images in the image processing. Through visual stimulation, it can arouse autistic students' interests in learning, attract their attention, improve their understanding, and help them better understand the basic degree courses.

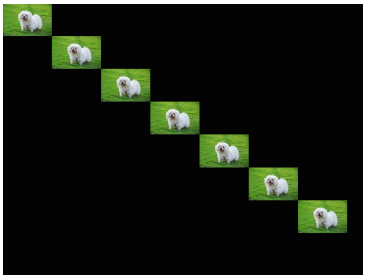

Fig. 4. The data matrix image after transformation

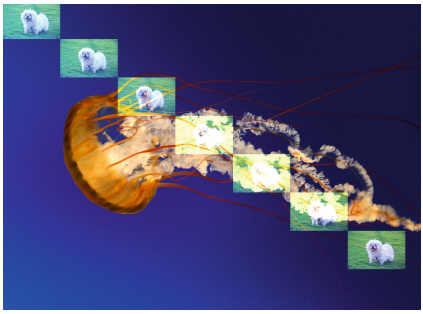

Fig. 5. The image after matrix addition

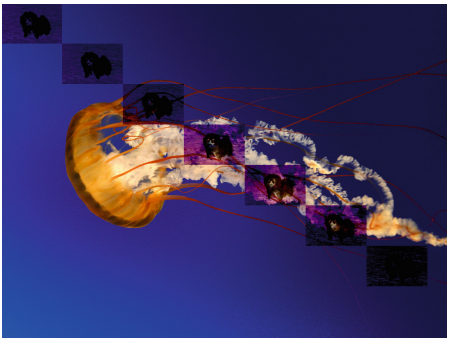

Fig. 6. The image after matrix subtraction

The problem of linear correlation and maximum linear independent groups can also be presented with the help of image visual effects. Each image in the image set can be

pulled into a vector, and then the image set can be represented in the form of a matrix. Use the Matlab to process the image data matrix and get the primary transformation, identify the maximum linearly independent group of the data matrix, display the image corresponding to the maximum linearly independent group, and analyze the difference of images. It can help autistic college students develop a more intuitive understanding of the vector maximum linearly independent group. And from the intuitive visual effect, the similarity of linear correlation images is analyzed. Improve the concentration of autistic college students through visual stimulation, and help them better learn basic degree courses.

3 Supervised and Mutually-Aided Learning Intervention

Compared with normal students, autistic students have relatively weak comprehension, relatively slow response ability, and relatively short attention span [5–15]. Therefore, for autistic college students in integrated education, their learning of degree courses needs more attentions and intervention from teachers. Taking the study of Linear Algebra as an example, this article proposes a supervised and mutually-aided learning intervention strategy for the study of degree courses of autistic college students with social dysfunction, explores how to implement educational intervention and rehabilitation for autistic college students at the higher-level education stage, and presents effective educational intervention methods for autistic college students' study of degree courses. Autistic students have the typical characteristics of autism, with poor understanding, short attention span, and obvious social dysfunction. In view of the characteristics of autistic students, we adopt different forms of educational intervention from three aspects, that is, classroom teaching, after-class Q&A and group discussion, to improve the efficiency of course learning and achieve a more ideal course learning effect.

3.1 Classroom Teaching

We know that the attention span varies for everyone, and the attention span of autistic students is relatively short. Therefore, for a new course, the teacher adopts a teaching method suitable for the class to attract students' attention to the study of the course. Take the calculation of matrix in Linear Algebra for example. Use the gray image to explain the addition, multiplication and scalar multiplication of matrix and use the Matlab to display the calculation results through images, which can help students form a more intuitive understanding of matrix operations and algorithms. Prolong the attention span of autistic students through different visual stimuli. In addition, in the classroom practice session, the teacher can observe the autistic students' practice and ask them questions to know about their learning situation, thus formulating a later strengthening plan. All in all, during the teaching process of new lessons, the teacher will conduct supervised learning intervention and attract the autistic students' attention to the newly taught knowledge through different methods, and help them understand the knowledge.

3.2 After-Class Q&A

Thanks to the development of smart phones, tablets and social software, it is very convenient for autistic students participating into after-class Q&A. The use of social software

transforms everyone's conversations with autistic students into man-machine conversations through text or voice, reducing the autistic students' anxiety in personal communication, and making it easier for autistic students to understand the problem. The teacher can list the key points of each new lesson through social software, which will help autistic students to further strengthen the knowledge learned in the classroom and feed the incomprehension knowledge back to the teacher through the social software. The teacher will give further detailed analysis of the incomprehension knowledge for autistic students in the form of voice and draft to strengthen the autistic students' understanding of new lessons. At the same time, the teacher assigns the exercises corresponding to the key points of the new lesson to the autistic students through social software. The autistic students reply the completed results to the teacher by means of taking photos, and the teacher can learn about the learning situation of autistic students through their exercise feedback.

At the same time, the teacher can select some students based on the classroom teaching response and observation, and allow them to participate in the autistic students' after-class Q&A session, conducting social intervention for the autistic students to communicate with others. Meanwhile, the communication between normal students and autistic students can enhance people's understanding of autistic students, and also let autistic students to know their classmates, and help autistic students take the first step in active communication. In addition, normal students will feed the autistic students' Q&A session and their learning situation back to the teacher. Based on the feedback, the teacher will formulate new Q&A session suitable for the individual characteristics of the autistic students, so that the autistic students can better understand the knowledge. It will achieve social intervention during the cooperative learning process. This cooperative learning model, on the one hand, cultivate the sense of responsibility of normal students, helping them to learn new knowledge better and be responsible for their activities during the Q&A session; on the other hand, it also allows normal students to have a comprehensive understanding of autistic students, so that they can keep a healthy value in terms of interacting with autistic people when they enter the society, which gives autistic people fair social opportunities and social interactions. Besides, it realizes the learning intervention and social intervention for autistic students and under the supervision of problem tasks guides autistic students take the initiative to communicate. Therefore, in the supervised and mutually-aided learning intervention process, it can help autistic students master the knowledge of the course, guide them to lead communication, and cultivate normal students' problem-solving skills.

3.3 Group Discussion

Group discussion is an effective intervention method for autistic students with social dysfunction. Considering the characteristics of the course and the learning situation of autistic students, we design a group discussion mode that gives the dominant position of autistic students, and help them to establish self-confidence in study. Take the Linear Algebra for example. The study of this course mainly examines the students' comprehension and calculation ability. The two autistic students in grade 2017 and 2018 have similar calculation ability with other normal students, or even better. They have no difficulties with the calculation of determinant, the rank of matrix, and calculation

of equations. In the final examination paper test, their core rate is relatively ideal. But in terms of the calculation ability for logical understanding, autistic students are relatively weaker than most normal students. For example, find the maximum linearly independent group of the vector group. The problem is solved in two steps. The first step is to augment the vector group into a matrix and turn it into a ladder-shaped matrix. The second step is to find corresponding column of the first non-zero element of each non-zero row of the ladder-shaped matrix, and the corresponding vector belongs to the maximum linearly independent group. Autistic students can complete the first step but come across difficulties in the second step. Only through intensive exercises of similar problems, can autistic students find the solution independently. The effectiveness of learning intervention through intensive exercises also shows that autistic students have the ability to learn. Through the intensive training, autistic students can master the method of finding the maximum linearly independent group of vector group, expanding the thinking longitudinally. This kind of intervention is not only a repetitive intervention, but also a natural intervention. Because the key points of knowledge are the same but the exercises are different, autistic students can better master the knowledge of finding the maximum linearly independent group of vector group and potentially complete the training of thinking when they are doing the exercises. Finding the maximum linearly independent group of the vector group belongs to the two-layer knowledge structure, and the eigenvalue eigenvector of the matrix belongs to the three-layer knowledge structure. The first layer calculates the characteristic polynomial of the matrix, and the second layer calculates the eigenvalue of the matrix according to the characteristic polynomial. The third layer calculates the eigenvectors of the matrix based on the eigenvalues. Through the integrated classroom, autistic students may only know how to find the characteristic polynomials of the matrix, and it is difficult to realize the subsequent layers. Therefore, during the after-class Q&A session, the teacher can help autistic students do more exercises to understand the problem-solving approach, training their way of thinking. In the constant or changing process, it can train the logical thinking ability of autistic students. In our follow-up integrated classroom design, we will continue to focus on the training of autistic students' logical thinking ability based on the course of Linear Algebra, and explore the impact of Linear Algebra-based logical thinking intervention training on other math courses.

After the intervention of problem-solving training, a group discussion that gives the dominant status of autistic students is implemented to realize the natural social intervention. For example, conduct group discussion on how to achieve the diagonalization of symmetric matrices. Include the autistic student and normal students in one group and the autistic student serves as the group leader who feed the results of the discussion back to teacher. In this process, the autistic student needs to communicate with each member of the group in order to complete the task. He or she must collect and summarize the problem-solving ideas, extract key information to obtain the correct solution, and give feedback to the teacher. The process of the autistic student collecting problem-solving ideas is actually an intervention process of active communication. Use tasks to guide the autistic student to communicate with normal students, and help them to learn normal human interaction. The process of the autistic student summarizing problem-solving ideas is actually a process of showing themselves to normal students so that normal

students can form a more comprehensive understanding of autistic students, preparing for later group discussion as well as the social communication intervention for autistic students. Help autistic students adapt to group communication and study, and overcome social dysfunction, accumulating experiences in interpersonal communication for the future. Help them to reduce fear and make communication a habit of independent living for autistic students.

Individual comment is another form of group discussion, such as using elementary row transformation to calculate the inverse of the matrix. Let autistic students and Tibetan students write the solution process on the blackboard, give each other a comment on the result, and help them master the method of finding the matrix inverse through elementary row transformation. This process contains two main bodies of the integrated education mode. One is the integration of autistic students and normal students, and the other is the integration of Tibetan students and students from the east. This specific problems-based test can enable the teacher to more specifically understand the degree of mastery of basic knowledge of students. The supervised and mutually-aided learning intervention strategy based on group discussion can not only help autistic students overcome communication barriers and study in integrated classroom, but also enable normal students to have a correct understanding of autistic students, promoting communication between autistic students and normal students.

In short, we hope autistic students can acquire the main points of the new course in the integrated classroom. Through the after-class Q&A session, autistic students can intensively practice the key points of the new course and achieve the expanded training of logic thinking in the problem solving process. At the same time, conduct natural social intervention on autistic students by means of group discussion, in which autistic students will be given a dominant position. Thus autistic students can learn normal social communication with others and realize pre-training for social communication until they leave school for the society.

4 Conclusion

This article takes the Linear Algebra course of Nanjing Normal University of Special Education as an example to explore the use of visual stimulation in the integrated classroom to extend the attention span of autistic students and help them adapt to the teaching mode of the integrated classroom. The task-driven approach can help autistic students take initiative to communicate with normal students, achieving the natural social interventions for autistic students. It can guide autistic students to actively ask questions or give answers, and actively seek help. At the same time, normal students can have a comprehensive understanding of autistic students and establish a correct social interaction values. The learning of different knowledge of Linear Algebra can train the autistic students with the ability of knowledge transfer and longitudinal development of thinking. In follow-up research, we will continue to focus on the key knowledge learning of autistic students based on the course of Linear Algebra, and explore which part of the knowledge in Linear Algebra is crucial for autistic students to learn the course, and propose a teaching and learning program suitable for autistic students to study the Linear Algebra.

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