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Article

Revolutionizing molecular and cellular biomechanics research: The impact of innovative English curriculum in biological sciences

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Abstract: This study focuses on the crucial role of English curriculum construction in biological sciences for molecular and cellular biomechanics research. Taking a school's biotechnology major as an example, it analyzes the existing problems in current English courses and teaching methods. By applying theories like spiral curriculum and constructivism, teaching materials and classroom methods are updated. The results show that this reform significantly improves non-native English speakers' professional English abilities in the field of molecular and cellular biomechanics. Specifically, it promotes the development of scientific thinking and expression skills, which is expected to enhance international communication and collaboration in molecular and cellular biomechanics research, thus directly contributing to the progress of this research field in China.

Keywords: molecular and cellular biomechanics; biological sciences English curriculum; curriculum reform; scientific thinking cultivation; professional English ability; biomedical research promotion

1. Introduction

Molecular and cellular biomechanics is the commanding point of the development of biotechnology in the 21st century, and it is an important task of higher education to train students majoring in biotechnology who master cutting-edge scientific and technological information [1,2]. As an international communication language, English for biotechnology is playing an increasingly important role in the timely acquisition and sharing of biotechnology information [3–6]. New biotechnology professionals must be proficient in English terminology and common expressions related to biotechnology, be able to consult and translate English materials smoothly, and keep abreast of the latest international developments in related fields [7–9]. In addition, it is necessary to have a certain degree of biotechnology English expression ability, and be able to communicate with international counterparts through written and oral means [10–12]. English courses for biotechnology majors have the characteristics of both language courses and specialized courses, which are not only an extension of basic English, but also significantly different from basic English in terms of vocabulary and sentence pattern expression [13,14].

Compared with the daily English, the biological sciences professional English less use of rhetorical devices, the text also rarely see a large portion of the emotional description, in the specific expression of the third person, the logic of the text is clear, which helps readers more intuitive understanding of the relevant professional knowledge, to master the cutting-edge dynamics and achievements of the field [14–16]. Therefore, colleges and universities need to change the concept of English education and teaching in biological sciences in a timely manner, and closely combined with the diversified needs of the development of the times, and strive to improve the overall level of English education and teaching in biological sciences.

In this paper, Spiral Curriculum, Constructivism Theory and SOLO Classification Theory are used as the theoretical basis for the design of the teaching mode of the Bioscience English course, and the learning progression framework is used to design the teaching process of the Bioscience English course. According to the tracking of learning trajectories and the planning of multiple learning stages, in order to realize the teaching of the Bioscience English course that focuses on the cultivation of scientific thinking and expression skills. Referring to the questionnaire scales of scientific thinking and expression ability of non-native English speaking students in related studies, we designed a questionnaire for the development of scientific thinking and expression ability of non-native English speaking students in the English language curriculum of biological sciences. The reliability of the questionnaire was then tested by using Cronbach's coefficient, KMO and Bartlett's test of sphericity. Finally, a teaching practice experiment was set up to investigate the effects of the English for Biological Sciences program on the development of scientific thinking and expression ability of non-native English-speaking students by comparing and analyzing the results.

2. Teaching design of English course in biological science based on learning progression

2.1. Theoretical foundations

2.1.1. Spiral curriculum

The so-called "spiral" [17] refers to the fact that along with the gradual maturation and complexity of students' thinking development, the same concept can be continuously expanded and deepened at different stages, and appear repeatedly at multiple levels from low to high. Spiral curriculum theory suggests that the core of English curriculum design in biological sciences is the basic concepts and principles of the subject, which should be placed at the center and presented in a form that is consistent with the direction of students' thinking development. Understanding and application of these basic concepts and principles increases as students grow older, so that they spiral through the curriculum. The learning progression, as a coherent and typical description of a thinking or learning pathway, also focuses on a low to high level of thinking, which is consistent with the idea of a spiral curriculum.

2.1.2. Constructivist theory

According to constructivism [18], the process of learning is not a process of transferring knowledge from the teacher to the student, but a process in which the student builds his or her own knowledge. The key to constructing lies in the learner's forming and adjusting the structure of his or her own experience through repeated interactions between old and new knowledge and experience. In this process of construction, on the one hand, the learner's understanding of the current information needs to be based on the original knowledge and experience, beyond the external information itself. On the other hand, the application of the original knowledge and experience requires the individual to make some adjustments and modifications to the original experience itself based on the new experience. Therefore, in the teaching design of the English course of biological science based on learning progression, it is also emphasized that we should start from the original knowledge, i.e., the starting point of progression, and on the basis of the original knowledge and experience, we need to comply with the cognitive development of the students and realize the gradual improvement.

2.1.3. SOLO classification theory

The SOLO classification theory [19] suggests that the level of students' responses to a specific problem can be categorized into five different levels, which are the pre-structural level, the single-point structural level, the multi-point structural level, the associative structural level, and the extended abstract structural level. These five levels mark the gradual transition of learners' cognitive level from low to high, from simple to complex. Moreover, SOLO classification theory has a unified psychological basis with the Learning Progression, and using SOLO classification theory as a reference tool to evaluate the results of scientific thinking and expression ability development of non-native English speakers in the teaching of English language courses in biological sciences can also fill the gap of the Learning Progression in the analysis of the ability development, and realize the advantages of mutual complementation.

Through spiral curriculum, constructivism theory and SOLO classification theory, the author updated the learning content, reformed the teaching methods and examination methods of biological science English courses, aiming at improving the interest of biology majors in learning professional English and achieving good results in cultivating students' professional English quality. Only through continuous exploration, practice and summary, can we find effective teaching methods, train senior biotechnology talents to adapt to the development of today's society, and indirectly promote the development of molecular and cell biology in China.

2.2. Instructional design process

Combined with the theoretical basis proposed above, this paper constructs the teaching design process of the English course in biological sciences, and the specific teaching process is shown in **Figure 1**. The teaching process of the English course in biological sciences is mainly divided into the design module, the development module and the feedback module.

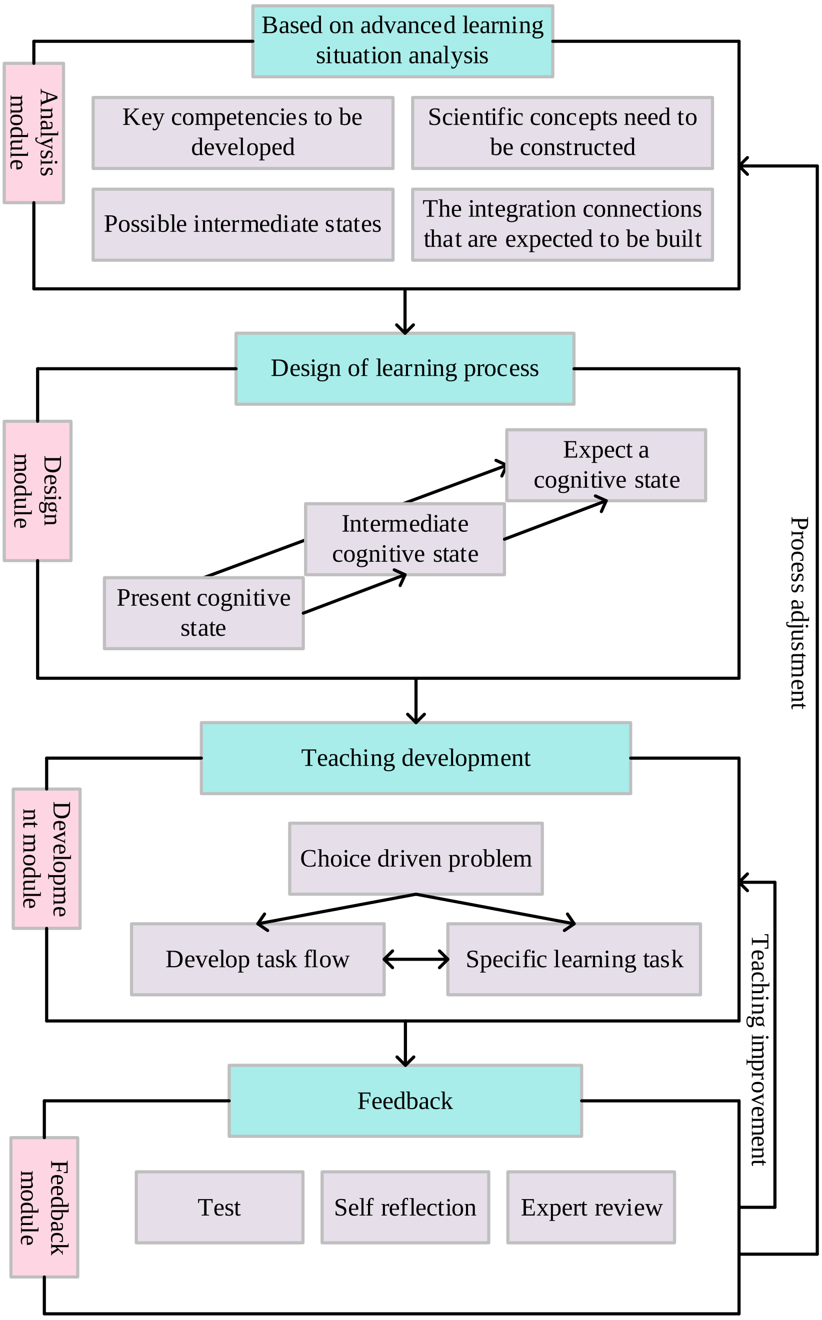


Figure 1. The teaching design of the English course of biology.

(1) Design Module

The instructional design module of the English course of biological sciences needs to design the overall learning trajectory based on the analysis of the learning situation. The learning trajectory here is multi-segmented. Multi-segmented means that the learning trajectory usually involves several levels of progressive development and requires planning for multiple learning stages. Multiple means that the learning trajectory usually involves several developmental dimensions such as conceptual understanding and key competencies, i.e., concepts to be constructed, scientific thinking skills to be developed, and concepts, attitudes, and responsibilities with which to integrate, as identified in the analysis module. Learning trajectories are therefore designed with due consideration of multiple developmental dimensions and the integration links between them.

(2) Development Module

The development module is based on the analysis of the teaching situation and the design of the learning trajectory of the English language course in biological sciences, using the learning trajectory as a script and the well-designed driving questions and tasks as a starting point to formulate the task flow and specific learning tasks, and to complete the progression between multiple learning stages. Good driving questions and tasks should stimulate students' interest and motivation to learn, making students have the desire to think and the motivation to explore. They should also be consistent with the trajectories of non-native English learners at different stages of learning in the English for the biological sciences program, with different problems to be solved at each stage of learning, so appropriate questions that can help to move across the stages of learning should be set according to the different stages of learning. They also need to be pedagogically feasible, achievable in the classroom and inspiring for subsequent learning.

(3) Feedback module

Feedback module means that after completing the teaching of the English for Biological Sciences program, feedback on teaching can be obtained through tests for non-native English speakers, self-reflection, and so on. Appropriate test questions can be chosen to correspond to each level of scientific thinking and expression, and based on the students' responses, they can judge whether they have reached that level and the end point of progression, providing better guiding experience for improving teaching and adjusting the learning process.

3. Measurement of students' scientific thinking and presentation skills

3.1. Questionnaire development

(1) Questionnaire for scientific thinking ability cultivation

Based on the connotation definition and level division of scientific thinking in the English curriculum standard for biological sciences, this study compiled a questionnaire for scientific thinking cultivation in the English curriculum for biological sciences with reference to the questionnaire content of scientific thinking ability of secondary school students in related studies [20]. The questionnaire is divided into six dimensions, which are six aspects of scientific thinking ability, including comparison and classification, induction and deduction, abstraction and generalization, analysis and synthesis, critical thinking and creative thinking. The questionnaire adopts a five-level Likert scale method, and each question is set with five different options: "completely disagree", "basically conform", "uncertain", "basically conform", and "1 = completely disagree, 2 = basically conform, 3 = uncertain, 4 = basically conform, 5 = completely conform" is given to each of the five options. In order to improve the accuracy of the questionnaire results, some questions are asked in reverse, and the corresponding options are assigned as "1 = fully agreeable, 2 = basically agreeable, 3 = uncertain, 4 = basically non-compliant, 5 = not at all". Non-native English-speaking students in the English for the biological sciences course were asked to choose answers to questions about the extent to which the phenomena described in the questions corresponded to their own situation, so that the findings could be analyzed on the basis of the students' responses. The final score of the questionnaire can visualize the level of scientific thinking development of non-native English-speaking students in the teaching of English language courses in biological sciences, and the higher the score, the higher the level of scientific thinking development. After completing the first draft of the questionnaire, experts and frontline teachers reviewed the composition of the questionnaire and the setting of the questions, and comprehensively evaluated the quality of this questionnaire development. Taking into account the suggestions of experts and frontline teachers, the questionnaire was revised and improved in time, and a small number of students were selected to participate in the trial test of the questionnaire.

(2) Questionnaire on the development of expressive ability

Expressive ability [21] is a reflection of the depth of thinking of non-native English speakers in the teaching of English for the biological sciences, which is mainly manifested through thinking methods, thinking forms or thinking procedures, and is manifested in the analysis, synthesis, comparison, questioning, interpretation, and ideas for dealing with certain specific problems. It is difficult to accurately judge the strength of a student's expression ability from the substance if it is detached from this series of manifest forms of expression ability. For example, some students are very stable and skillful in the use of problem solving methods for test questions in the English language program in biological sciences, or they are very strong in problem solving, but this does not mean that their expression ability is very strong, so when selecting and compiling test questions to test the strength of a student's expression ability, it is necessary to start from the examination of whether a student Therefore, when selecting assessment questions to test students' expressive ability, it is necessary to select test questions from the perspective of examining whether students have the ability to apply the written language, symbolic language and graphical language of biological sciences to solve real problems. Therefore, the questionnaire was designed to examine the ability of non-native English speakers to express themselves in the English course of biological sciences in terms of the consistency and scientificity of the content of the expression (the construction of expression), the logic and simplicity of the process of expression (the transformation of expression), and the standardization of the result of the expression (the operation of expression). The questionnaire also utilized a five-point Likert scale, with different values assigned to each of the five options, "1 = not at all, 2 = mostly, 3 = not sure, 4 = mostly, 5 = fully".

3.2. Reliability test

Before formally conducting a questionnaire survey, it is usually necessary to test the reliability and validity of the questionnaire in order to objectively evaluate the comprehensive quality of the questionnaire. Therefore, this study randomly selected a portion of survey respondents for a small-scale pilot test before the formal survey. In this pre-survey of the questionnaire, a total of 100 students were randomly selected to distribute the questionnaire, and finally 100 valid questionnaires were recovered, with a recovery rate of 100%.

3.2.1. Reliability analysis

Reliability reflects the reliability and stability of a questionnaire; the higher the reliability, the more authentic the findings. Using SPSS software, Cronbach's Alpha (Cronbach's coefficient) was used for measurement, the reliability value ranges from 0–1, the larger the value the higher the reliability. This questionnaire was utilized to test the reliability of the results using SPSS software. The reliability of the two sub-dimensions of the questionnaire on the development of scientific thinking and expression of non-native English-speaking students is greater than 0.7, and the overall reliability of the questionnaire is 0.912, which is close to 0.9, which indicates that the questionnaire has good reliability, high reliability and stability, and it can be investigated.

3.2.2. Validity analysis

Validity is the basic scale that reflects the validity of the measurement data, pointing to the validity and accuracy of the questionnaire, measuring whether the questionnaire can actually detect the content of the target that it wants to examine. This questionnaire was utilized with SPSS software and the results were tested for KMO and Bartlett's sphericity. The results of the validity analysis are shown in **Table 1**, where A1–A6 stand for comparison and classification, induction and deduction, abstraction and generalization, analysis and synthesis, critical thinking and creative thinking. B1–B5 stand for consistency, scientificity, logic, conciseness and normality. The KMO values of the sub-dimensions in both questionnaires were greater than 0.7, and the overall KMO values of the questionnaires were 0.875 and 0.897, respectively, which were greater than 0.8, so there was a correlation between the question variables, which was in line with the requirements of factor analysis. Meanwhile, the results of Bartlett's sphericity test showed that the significance levels were all 0.000, which presented significance at the level, and there was correlation between the variables, and the factor analysis was valid. It can be seen that the results of this questionnaire match the objectives to be examined to a high degree and can be formally used for the status quo survey.

Table 1. Validity test of student questionnaire.

Scientific thinking questionnaire								
Dimension		**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**General**
KMO	——	0.704	0.783	0.766	0.782	0.719	0.793	0.875
	Approximate card	133.93	145.43	179.76	160.73	141.93	137.78	452.36
Bartlett	Freedom	5	5	5	5	5	5	5
	Sig.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ability questionnaire								
Dimension		**B1**	**B2**	**B3**	**B4**	**B5**	**General**	
KMO	——	0.749	0.772	0.733	0.771	0.706	0.897	
	Approximate card	159.89	179.32	179.23	159.34	134.19	511.23	
Bartlett	Freedom	5	5	5	5	5	5	
	Sig.	0.000	0.000	0.000	0.000	0.000	0.000	

4. Analysis of the teaching effect of the English course of biological sciences

The Chinese writing system is different from phonetic writing in its ability to express phonetics and semantics. Phonetic writing, like the English writing system, represents speech sounds through morphemes. Chinese characters, on the other hand, combine words with syllables in the shape of a box, and no part of this box system can be regarded as a phonetic component (such as a segment). The two most important brain regions are the left medial frontal gyrus (MFG) and the right fusiform gyrus. As for the left medial frontal gyrus, it is a specific processing brain area of English reading and is related to the speech addressing processing of English text. The posterior part of the left superior temporal gyrus is the brain region that responds specifically to the reading process of the phonetic system, and is mainly responsible for the assembly of phonetic sounds.

4.1. Subjects of study

Between the beginning of September 2023 and the beginning of December 2023, this paper presents a three-month practical study of teaching and learning English language courses in biological sciences in a school. Two classes, both of which were non-native English speakers, were selected for the study to analyze the significant differences in the pre-test levels of scientific thinking and expression of the students in the two classes. Class E was randomly selected as the experimental class and Class C was selected as the control class, and the teaching practice of the English course in biological sciences was carried out in Class E. Class E was taught the English course in biological sciences based on theories of learning progression and constructivism, while Class C was taught in biological sciences according to the traditional conventional teaching method, with the same teacher, and the teaching progress of the two classes remained the same. The teaching process is the same teacher, while the teaching progress of the two classes is consistent.

4.2. Pre-test analysis of teaching practices

An independent samples t-test was conducted on the mean values of the questionnaires on the dimensions of scientific thinking skills and expressive skills of Class E and Class C before the experiment to investigate whether there was a significant difference between the two groups. The results of the comparative analysis of the scientific thinking and expression skills of the non-native English speaking students in the two classes before the teaching practice was carried out are shown in **Table 2**. Through the test, it was found that there was no significant difference between class E and class C in all dimensions in scientific thinking skills before the experiment, and the p-value was greater than 0.05 (p = 0.446, 0.430, 0.756, 0.731, 0.406, 0.873), which means that there is no significant difference between the two classes in the level of scientific thinking skills, which can be selected for the study. In terms of expression ability, there was no significant difference between the survey scores of the consistency of expression content ($P = 0.235 > 0.05$) and scientific ($P = 0.289 > 0.05$), the logic of the expression process ($P = 0.712 > 0.05$) and conciseness ($P = 0.525 > 0.05$) and the standardization of expression results ($P = 0.413 > 0.05$).

Table 2. The analysis of the thinking and expression of student students.

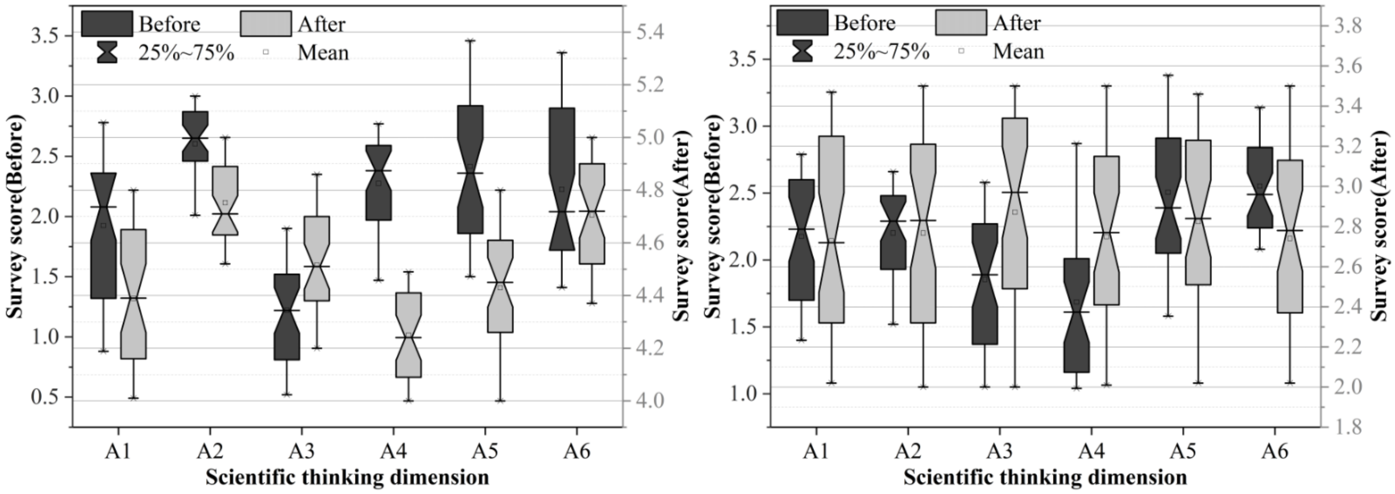
Dimension		Class E		Class C		*T*	*P*
		Mean	**SD**	**Mean**	**SD**		
Scientific thinking	Comparison and classification	1.93	0.58	2.18	0.59	−0.044	0.446
	Induction and deduction	2.60	0.5	2.20	0.97	0.049	0.43
	Abstract and generalization	1.22	0.8	1.85	0.73	0.033	0.756
	Analysis and synthesis	2.28	0.88	1.69	0.75	0.169	0.731
	Critical thinking	2.42	0.62	2.51	0.95	0.288	0.406
	Creative thinking	2.23	0.69	2.55	0.87	−0.336	0.873
Expressive power	Consistency	2.16	0.61	2.36	0.61	−0.307	0.235
	Scientificity	3.17	0.72	2.50	0.78	−0.308	0.289
	Logicality	2.04	0.88	1.86	0.8	0.514	0.712
	Simplicity	1.58	0.81	1.66	0.9	−0.203	0.525
	Normality	2.01	0.64	2.14	0.54	0.005	0.413

4.3. Feedback analysis of post-test of teaching practice

In order to test that the teaching of English for the biological sciences can more effectively promote the development of students' scientific thinking and expressive ability, a post-test was conducted on Classes E and C after three months of teaching practice to test the promotion of the teaching of English for the biological sciences on the development of students' scientific thinking and expressive ability and provide some references to the current situation when frontline educators use the English for the biological sciences teaching based on the progression of learning to promote the development of students' scientific thinking and expressive ability. It also provides a reference for frontline educators to use the English for Biological Sciences program based on learning progression to promote the development of students' scientific thinking and expressive ability.

4.3.1. Analysis of the results of the scientific thinking scale

This Scientific Thinking Scale has been tested once on the students before carrying out the teaching practice of Biological Sciences and the results showed that there was no significant difference in the level of scientific thinking of the students in class E and class C. In order to test whether the teaching practice could contribute more to the development of students' scientific thinking, therefore, a post-test questionnaire was administered to the students in this study. After analyzing the results of the questionnaire on the development of scientific thinking ability as a whole, the obtained results of the students' scientific thinking level self-assessment are shown in **Figure 2**, with **Figure 2a,b** representing the results of the comparative analysis of the development of scientific thinking ability in the pre- and post-tests of Class E and the pre- and post-tests of Class C, respectively. A1–A6 in the figure represent comparison and classification, induction and deduction, abstraction and generalization, analysis and synthesis, critical thinking and creative thinking. By analyzing and comparing the total scores and the mean scores of each dimension of the scientific thinking level of students in Classes E and C, it can be seen that the total scores and the mean scores of each dimension of the scientific thinking of students in Classes E and C have improved, and the improvement of students in Classes E compared with those in Classes C is more obvious. The scores of Class E students on the dimensions of Comparison and Classification and Induction and Deduction improved to 4.39 and 4.75 from 1.93 and 2.60 before the implementation of the teaching practice, while the mean survey scores of Class C students on these dimensions improved to 2.73 and 2.77 from 2.18 and 2.20.



(a) Class E (Before and after) **(b)** Class C (Before and after)

Figure 2. The scientific thinking ability is developed after the analysis.

Subsequently, SPSS statistical software was used to further statistically analyze the level of scientific thinking skills development of the students in the two classes, and the results of the comparison of the level of scientific thinking skills development of the students in the two classes on the post-test of teaching practice are shown in **Table 3**. It was found that the difference between the mean scores of the self-assessment questionnaires on scientific thinking of the two classes was 10.36, with a significance of $P = 0.000 < 0.01$. The P-values of the dimensions of scientific thinking were 0.019, 0.014, 0.001, 0.004, 0.004, 0.004, and 0.008, indicating that there was a significant difference between them in the areas of comparing and categorizing, inducting and deducing, abstracting and summarizing, creative thinking, analyzing and synthesizing, critical thinking, and critical thinking. There are significant differences in all areas. The post-test data can be obtained that there is a significant difference in the level of scientific thinking between the two classes, thus proving that the development of this teaching practice for scientific thinking improvement in the English language course of biological sciences has a more significant improvement effect compared to the way of teaching the ordinary biological sciences course.

Table 3. The comparison between the E and the C.

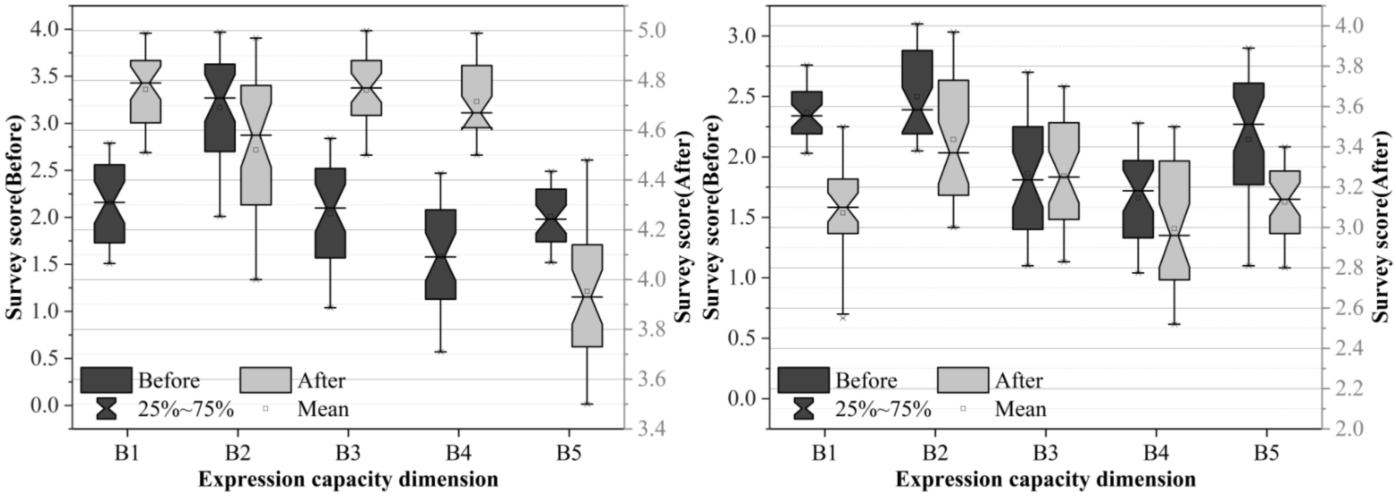
Dimension	Class E		Class C		*T*	*P*
	Mean	SD	Mean	SD		
Comparison and classification	4.39	0.59	2.73	0.73	2.272	0.019
Induction and deduction	4.75	0.66	2.77	0.94	3.091	0.014
Abstract and generalization	4.52	0.66	2.87	0.92	2.522	0.001
Analysis and synthesis	4.25	0.96	2.75	0.67	2.312	0.004

Table 3. (*Continued*).

Dimension	Class E		Class C		*T*	*P*
	Mean	SD	Mean	SD		
Critical thinking	4.43	0.66	2.83	0.64	2.173	0.004
Creative thinking	4.71	0.58	2.74	0.67	3.088	0.008
Total	27.05	4.65	16.69	3.48	4.526	0.000

4.3.2. Results of non-native English speaking students' expressive skills development

The results obtained from analyzing the expressive ability of the non-native English speaking students after implementing the teaching of the English language course in biological sciences are shown in **Figure 3**, **Figure 3a,b** represent the results of the comparative analysis of the expressive ability of the non-native English speaking students in Classes E and C before and after the carrying out of the teaching practice, respectively. B1–B5 in the figure represent consistency, scientificity, logic, conciseness and standardization. The results of the comparative analysis of the post-test expressive competence of the non-native English-speaking students in Classes E and C are shown in **Table 4**. Similar to the results of the above analysis on the development of scientific thinking ability level, the expression ability level of non-native English-speaking students in both Class C and Class E increased to a certain extent compared to the level before the teaching of the biological science curriculum was carried out. The expression ability of non-native English-speaking students in Class E in the posttest was above 4 points in all dimensions except for the normality of the expression results (3.95 points), which was significantly different from the pre-test level ($P < 0.05$). And the mean scores of consistency of expression content (4.76), logic of expression process (4.76) and simplicity (4.72) were all 4.7 and above, and the mean score of the dimension of scientificity of expression content reached 4.52 although there is still some room for improvement. There was a significant difference in the mean scores of all dimensions of expression content between Class E and Class C, except for the dimension of normativity of expression results, where no significant difference exists ($P = 0.512 > 0.05$), there is a significant difference in the mean scores of the other dimensions. This suggests that the three-month English course in biological sciences has contributed to the improvement of the non-native English-speaking students' level of expressive competence. In addition, from the analysis of the pre- and post-test levels of non-native English-speaking students' expressive competence in Class C, it can be seen that there is also a significant difference between the post-test level (3.44 points) and the pre-test level (2.50 points) in the dimension of scientificity of expressive content ($P < 0.05$), which indicates that the regular teaching of the Bioscience English program can also play a certain role in promoting the development and enhancement of expressive competence of the non-native English-speaking students. However, compared with the implementation of the teaching of the biological sciences English course based on the concept of learning progression, the coverage of the expressive competence dimension is lacking, and the enhancement of the expressive competence level of non-native English-speaking students is relatively slow. This also indicates that the teaching of the English for the biological sciences program has a wider coverage of the dimensions of expressive competence development for non-native English-speaking students, and the speed of enhancement of the development of expressive competence is also faster.



(a) Class E (Before and after) **(b)** Class C (Before and after)

Figure 3. The analysis of the analysis of the expression ability.

Table 4. Analysis of the students' expression ability in non-English speakers.

Dimension	Class E		Class C		*T*	*P*
	Mean	SD	Mean	SD		
Consistency	4.76	0.53	3.07	0.72	2.974	0.003
Scientificity	4.52	0.53	3.44	0.85	2.698	0.028
Logicality	4.76	0.92	3.25	0.8	2.682	0.022
Simplicity	4.72	0.65	2.99	0.67	2.883	0.02
Normality	3.95	0.57	3.13	0.74	3.381	0.051
Total	22.71	3.69	15.88	3.47	2.907	0.030

5. Conclusion

In this paper, we design the teaching process of the English course of biological sciences based on the theories of constructivism and learning progression, carry out the teaching practice of the English course of biological sciences, and use the questionnaire to collect the cultivation of scientific thinking and expression ability of the non-native English-speaking students in the teaching. The results showed that:

(1) There is no significant difference ($P > 0.05$) between the students of Class E, who were taught the English for Bioscience course before the teaching practice, and the students of Class C, who were taught the general Bioscience course, in the dimensions of scientific thinking ability and expression ability, which are homogeneous and can be selected as the research object.

(2) The total scores of scientific thinking and the mean scores of all dimensions of the students in Class E and Class C in the post-test of 3-month teaching practice have improved, and the comparison and classification of the students in Class E and Class C have improved to 4.39 and 2.73 from 1.93 and 2.18 before the teaching practice was carried out, respectively. It was also found that the difference between

the mean scores of the self-assessment questionnaire on scientific thinking in the two classes was 10.36 points, with a significance of $P = 0.000 < 0.01$. In addition, in the post-test analysis of the expressive competence of the non-native English-speaking students, the mean scores of the non-native English-speaking students of the post-test of the expressive competence of Class E were above 4 in all dimensions except for normativity of the results of the expression (3.95), which was a significance difference from the level of the pre-test ($P < 0.05$). It indicates that the teaching of the English course in biological sciences covers a wide range of the dimensions of students' expression ability development.

In conclusion, based on the theory of learning progression and other theories, the teaching of the English course in biological sciences can promote the comprehensive cultivation and development of scientific thinking and expression ability of non-native English speakers by targeting at the cultivation of the dimensions of scientific thinking and expression ability.

This study has some guiding significance for the reform and development of English teaching on how to improve the scientific thinking and expression ability of non-native English learners. However, there are still some shortcomings to be further improved and further studied. First, the scope of the study is not extensive enough. Limited by some conditions, the empirical research cannot widely select more students and classes for comprehensive investigation and experiment, and the research sample and quantity coverage are still relatively small. Second, the limitations of research tools. In the teaching experiment of human-computer symbiosis to improve English learning ability, it is applied in the classroom and teaching, because the research tools are limited, so the data obtained is single.

Author contributions: Conceptualization, JC and HG; methodology, JC; software, JC; validation, JC and HG; formal analysis, JC; investigation, JC; resources, JC; data curation, JC; writing-original draft preparation, JC; writing-review & editing, JC; visualization, JC; supervision, JC; project administration, JC; funding acquisition, HG. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest: The authors declare no conflict of interest.

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