Pilot Study on the Construction Plan of Biological Microelectronics Micro Major

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***Abstract*—Biological microelectronics is a hot topic in the research field of microelectronics, integrated circuits and biology in recent years. The School of Microelectronics in Shandong University exemplarily set up Biological Microelectronics Micro major in 2020. After the first stage of the courses, questionnaires were designed to investigate the evaluations and suggestions from the first batch of participants for the Bio-microelectronics introduction course. We also analyzed the achievements and shortcomings of the first-stage training program of the micro major, and put forward some suggestions that lead to improvements in the follow-up construction of biological microelectronics micro major. We also summarized valuable experience in the construction of cross-discipline in the field of biological microelectronics. This work will help to optimize training program of the biological microelectronics micro major.**

***Keywords*—bio-microelectronics, talent training, course evaluation, cross-discipline, questionnaire survey, training program optimization**

I. Introduction

Biological microelectronics has become a hot spot all over the world [1−5], and the training of corresponding interdisciplinary talents has become increasingly important. In response to social development's demand for Bio microelectronics compound talents [6−8], the School of Microelectronics in Shandong University had set up a micro major named Biological Microelectronics for undergraduates since 2020 [9, 10]. Before enrollment into the micro major, we have drawn up a preliminary training program for the micro major of biological microelectronics. In the first stage of the course, we set up the course "Introduction to Biological Microelectronics" to give a general introduction to the field of biological microelectronics, and at the same time explain the content covered by several main directions in the field of biological microelectronics [11], aimed at enhancing students' understanding of all directions, cultivating their interest, and laying a good foundation for them in the next stage of other biological microelectronics micro professional courses.

In the view of the fact that almost no colleges or universities offers similar majors to Bio-Microelectronics, there are few relevant cases for our reference. Our design of Bio microelectronics micro-professional programs needs to be continuously tested and evaluated in practice, to achieve continuous improvement and optimization, and to cultivate high-quality bio-microelectronics talents. This work collected feedback from dozens of students who participated in the study of biological microelectronics micro majors through questionnaires, and analyzed the results and shortcomings of the first phase of the micro major.

II. Methods

After the first-stage introduction course of the Biological Microelectronics major in the School of Microelectronics in Shandong University, we designed an anonymous questionnaire for students who signed up for the Micro Major. Then we conducted a research focusing on students' participation in the first stage of the course and evaluation feedback, as well as suggestions for subsequent courses.

A total of 41 valid questionnaires were returned after the survey period was over. Among them, 38 subjects participated in the course of bio microelectronics, and the other 3 subjects quitted. Among these 41 subjects, there were 15 students in grade 2019, accounting for 36.59%, and 26 students in grade 2020, accounting for 63.41%. The number of students majoring in Integrated Circuit Design and System is 14, 34.15% of all subjects. There are 27 students majoring in Microelectronics Science and Engineering, accounting for 65.85%.

III. Results

A. Research on the Teaching of Biological Microelectronics

1) Students' participation in the course

The results of the questionnaire survey showed that among the 38 students who participated in the micro-major "Introduction to Bio microelectronics" course, only

Manuscript received March 2, 2022; revised May 10, 2022; accepted July 23, 2022.

17 students participated in all courses, accounting for 44.74%; 12 students who attended classes less than 7 times, accounting for 31.58%, as shown in Fig. 1(a). In class, there are only 10 students who always listen carefully, accounting for 26.32%; 27 students just listen carefully occasionally, accounting for 71.05%, as shown in Fig. 1(b). The results show that about half of the students have missed class. Most students listened selectively. The emergence of this phenomenon shows that students pay insufficient attention to biological microelectronics. The conflict between the curriculum setting and the original major is also one of the reasons contributing to this phenomenon.

"Introduction to Biological Microelectronics" includes five homework assignments, including the final exam papers. More than 50% of the students didn't finish their homework except for the first homework and the fifth final exam, as shown in Fig. 1(c). The reason for the poor completion of the students' homework has two points. On the one hand, the professional academic tasks are heavy and there is no time to complete the homework of this course; On the other hand, it is because the students encountered a lot of difficulties when doing their homework. These are reflected in the research questions about the reasons for the incomplete assignments.

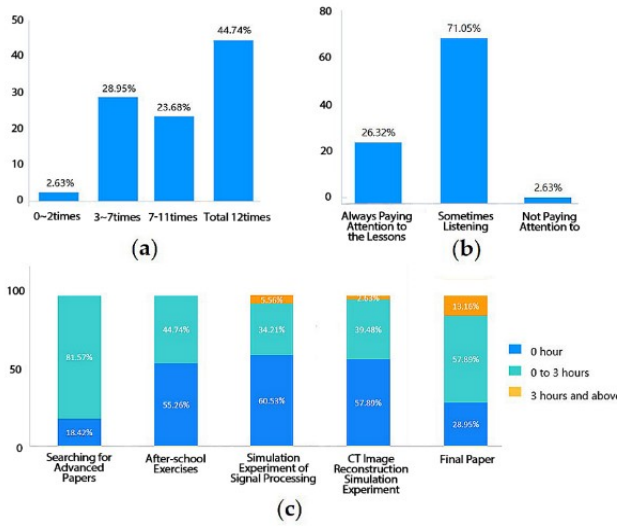

Figure 1. Feedback on course learning: (a) Number of classes for students majoring in the biological microelectronics micro major this semester; (b) students' performance of the students majoring in the biological microelectronics micro major in class; (c) The completion of homework of the students majoring in the biological microelectronics micro major.

The survey results also show that 19 of the 38 students participating in the course have done self-learning in bio microelectronics-related knowledge in their free time, and this proportion accounts for 50%, as shown in Fig. 2(a). Among those who have done extra study, those who studied 0.5−1 hour per week account for the largest proportion, accounting for 31.58%. There are even students who study extra hours per week for more than 3 hours, as shown in Fig. 2(b). Among the students who did not go an extra mile after class, the number of students who believed that professional courses took up their spare time was the largest, accounting for 68.42%, as shown in Fig. 2(c). This survey result shows that most of the students participating in the course have a strong willingness to learn bio microelectronics. If they are properly guided, the student's participation is likely to increase significantly.

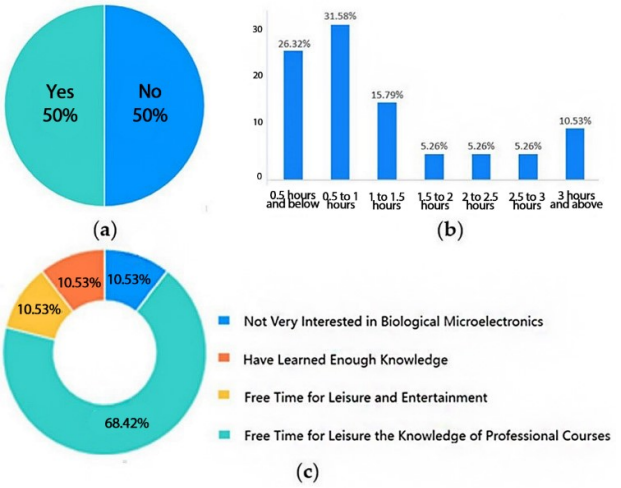

Figure 2. Participation feedback on coursework: (a) Will students majoring in the biological microelectronics micro major learn bio microelectronics knowledge independently in their free time; (b) Distribution of study time of the students who can learn knowledge in the field of biological microelectronics in their free time; (c) The reason why the student majoring in the biological microelectronics micro major did not learn knowledge in the field of biological microelectronics in their free time.

2) Students' feedback on the course

The results of the questionnaire survey for the class part showed that among the 38 students, 17 people thought that the content of the lecture was difficult, accounting for 44.74%; 13 people reported it's moderately difficult and has great gains, accounting for 34.21%, as shown in Fig. 3(a). This result shows that the teacher's explanation is a bit too in-depth in the teaching of the "Introduction to Biological Microelectronics". This may also affect the participation of students.

The results of the survey on the homework section showed that 25 of the 38 participants in the course believed that completing the homework was a great gain for them, accounting for 65.79%; while 34.21% of the students believed that completing the homework did not bring much gains and improvements. They just finished it out of habit. As shown in Fig. 3(b), one third of the students are not satisfied with the coursework. Among these dissatisfied students, 61.54% are dissatisfied because they think the homework is too difficult, and some people report that the homework is not reasonable enough, as shown in Fig. 3(c). Similarly, the survey on the reasons for not completing the homework revealed that among the students who did not complete all the homework, 48.15% of the students thought the homework was too difficult or was out of touch with the content of the class, and 40.74% of the students reported that the task of learning for the original major is too heavy, and there is no time to work on homework, as shown in Fig. 3(d). It can be seen that the degree of difficulty of homework, the

type of homework, and the limited time are important reasons for the poor completion of the students' homework.

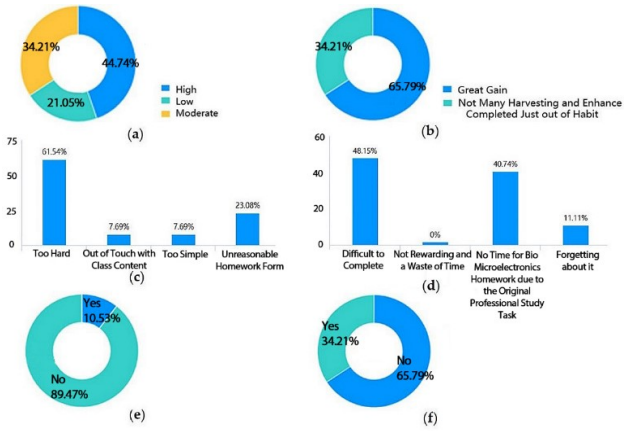

Figure 3. Course evaluation from students. (a) Evaluation of the difficulty of the course by students majoring in the biological microelectronics micro major; (b) Views raised by students majoring in the biological microelectronics micro major about whether or not the completion of the homework of will bring great gains; (c) The reason why students majoring in the biological microelectronics micro major think their homework for the biological microelectronics micro major did not bring much gain; (d) The reason why the student majoring in the biological microelectronics micro major did not complete all the homework for the biological microelectronics micro major; (e) Does the study of the course of the biological microelectronics micro major hinder the study of the original major; (f) Does the study of the course of the biological microelectronics micro major promote the study of the original major.

The questionnaire survey results also show that although participating in the study of biological microelectronics and micro majors takes up part of the students' time and energy, 34 of the 38 participants in the course believe that the learning on courses of the micro major did not have a negative impact on their professional courses, as shown in Fig. 3(e). On the contrary, 25 of these 38 people think that the micro-professional course study is helpful to their original professional learning and understanding, and this proportion reaches 65.79%, as shown in Fig. 3(f). Among the students who thought it would be helpful, the 19th grade accounted for 36%, the 20th grade accounted for 64%; the integrated circuit design and integrated system major accounted for 33.3%, and the microelectronic science and engineering major accounted for 66.7%, from which there is no obvious tendency for grade or major differences among the students who think helpful. The study of the professional courses of the two majors of the School of Electronics has a certain promotion effect.

B. Achievements and Reflections on the Construction of Biological Microelectronics Micro Major

1) Enlightenment of subjects' interest in the field of biological microelectronics

The results of the questionnaire survey showed that 29 of the 38 people who participated in the course were interested in the field of biological microelectronics, accounting for 76.31%. Among them, 13 students of no interest before were slowly interested in a certain direction after participating in the first-stage course of Biological Microelectronics Micro Major (Group 1), accounting for 44.83% of the total interested people; the number of students who have a detailed understanding of the direction of interest after studying (Group 2) is 7 people, accounting for 24.14%; and the number of students changed their interested field (Group 3) is 9, accounting for 31.03%, as shown in Fig. 4(a). The directions that students participating in the course are interested in before and after the first phase of the course are shown in respect in Fig. 4(b) and Fig. 4(c). The results show that the first-stage course of the biological microelectronics micro major enables students to have a comprehensive understanding of biological microelectronics, and cultivates students' interest in interdisciplinary subjects of biological medicine and microelectronics. The in-depth understanding has changed the interest of the students from centralized to decentralized, either.

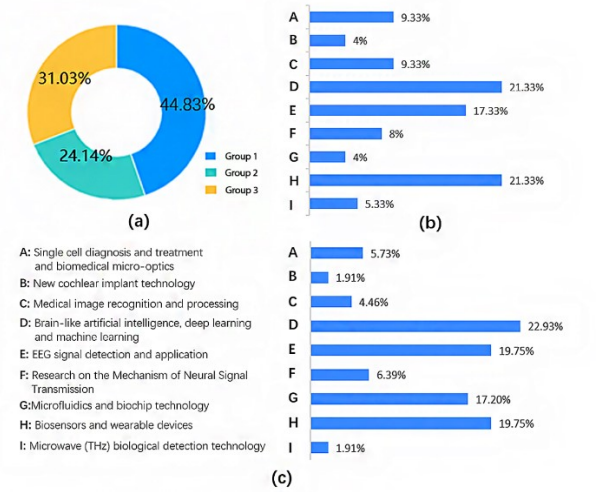

Figure 4. Changes in students' fields of interest: (a) Reasons why students majoring in the biological microelectronics micro major are interested in a certain field of bio microelectronics after the first stage of the course; (b) After the first stage of the course, Students' interest in various fields of biological microelectronics; (c) Before the first stage of the course, Students' interest in various fields of biological microelectronics.

2) Student's course selection in the next stage

The survey results showed that 28 subjects who participated in the course planned to continue the study of biological microelectronics micro major, accounting for 73.68%. The main reasons for students who gave up were that they did not have enough time and energy due to their heavy major, or that they were not interested in studying Biological Microelectronics.

The next course selection intention of the students who continue to participate in the course is shown in Fig. 5. Comparing the newest course selection intention survey results (Fig. 5(a)) with the previous results (Fig. 5(b)) before the first stage course, it can be seen that some changes have taken place in students' tendency to choose courses. In general, the elective courses selected for the training program of biological microelectronics including brain science and cognitive science courses, bio sensing and intelligent medical courses are still the courses that students tend to choose, and the number of students who

intend to choose the Introduction to Artificial Intelligence has been significantly reduced. The selection ratio of Biosensing and Smart Medicine, and Medical Signal and Image Processing has increased. These survey results will provide a basic reference for the optimization of our curriculum design and training program.

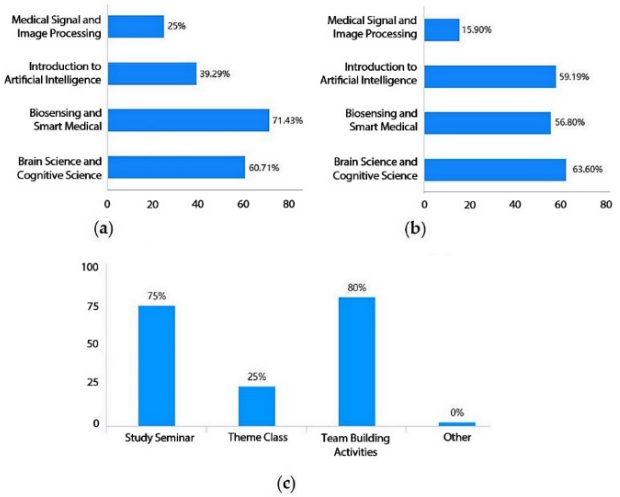

Figure 5. Respondents' feedback on preference for follow-up courses and teaching methods:(a) The intention of the students majoring in the biological microelectronics micro major is to choose follow-up courses after the completion of the first stage of the course; (b) The intention of the students majoring in the biological microelectronics micro major is to choose follow-up courses before the completion of the first stage of the course; (c) Support situation Among the students majoring in the biological microelectronics micro major who support rich teaching styles who for several teaching methods.

IV. Discussion

A. Achievements

This survey shows that the first stage of the "Introduction to Biological Microelectronics" course of the biological microelectronics micro major has achieved good results. The course has inspired and guided students' interest in different directions in the field of Bio microelectronics. Many students' interests have been stimulated, and their direction of interest has become clearer. They can choose to study different elective courses according to their own situation, and the teaching objectives of the first stage have basically been completed. At the same time, micro-professional study is also helpful to students' original professional study. From this survey, we can also find some shortcomings. For example, some students do not pay enough attention to the biological

microelectronics micro major class; in this introduction class, sometimes the teacher explains in a confusing or an unclear way, which makes it difficult for students to understand. This point may affect students' classroom participation, and in that case, they will struggle with the given homework due to lack of understanding and guidance. These issues need attention.

B. Suggestions

According to the survey, the foundation of the students will affect the participation of students in the classroom to a certain extent [12]. This point should be emphasized in the further training and cultivation. The students participating in the micro major are almost freshmen and sophomores whose foundation is relatively weak. In the future, we must pay attention to paving the way for students with weak basic knowledge to help them get started as soon as possible when lecturing.

The survey found that many students are going to do additional learning in the field of biological microelectronics after class. Therefore, it is necessary for teachers to provide some learning resources to guide students to learn more knowledge which interests them smoothly after class. The survey also shows that most students are eager for richer teaching methods. Among the 38 people who participated in the course, more than half agreed to enrich the teaching style, while less than 10% of the students felt that the current teaching style does not need to be changed. Among the students with supportive opinions, the support rate of learning seminars is 75%, the support rate of theme classes is 25%, and the support rate of team building is 80%, as shown in Fig. 5(c). These improvements are likely to further arouse students' interest in biological microelectronics learning and enhance students' participation in the classroom.

According to the survey, the completion of the students' homework needs to be improved. Time and energy are the main obstacles to completing assignments. The homework in future should be refined and the difficulty should not be high to minimize the occupation of their time and energy. This may improve the completion of students' homework to a certain extent, so as to better practice and consolidate the knowledge learned in class. At the same time, reducing the time occupied by homework can also promote their independent learning after class. Another problem is that students participating in the course, especially the freshman students, have insufficient ability to use various simulation tools and limited ability to mine various information and data. Therefore, it is necessary to give some introductory guidance to some tools and software that the students are not familiar with. The improvement of students' ability to complete homework may improve the completion of their homework, and they may be able to gain more in the process of completing the homework. The students' preference for the type of homework is shown in Fig. 6. The survey results show that students prefer two types of homework, literature research and simulation experiments. Most of them think that these two types of homework are more conducive to their own improvement. On the basis of comprehensive consideration of the teaching goals, teachers can assign the types of homework that students prefer, which may improve the completion of homework to a certain extent, so that students can gain more.

The main purpose of this survey is to summarize the experience of the first stage of the construction of the biological microelectronics micro major in our college, and to promote the further optimization and improvement of the biological microelectronics micro major training program. Therefore, the data obtained from the current

survey scope can support various conclusions. It is hoped that in the future, the research team will continue to conduct feedback investigations along with the construction and advancement of the biological microelectronics micro professional curriculum, continuously optimize the training plan of the college's biological microelectronics micro professional, summarize the experience of each stage of the micro professional construction, and provide it to other institutions and universities for reference to train a large number of excellent interdisciplinary talents in the field of Bio microelectronics for the school and the country.

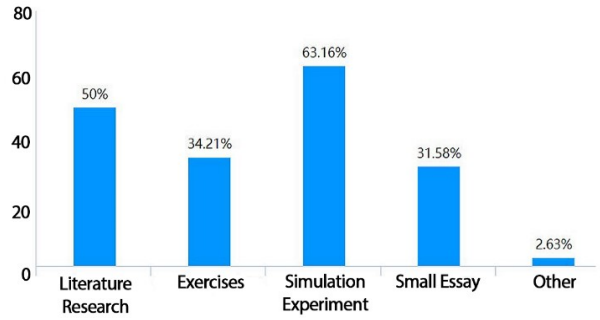

Figure 6. Preference of the students majoring in the biological microelectronics micro major for the type of assignment.

This survey excavated the construction results of the first phase of the bio microelectronics major of the School of Microelectronics of Shandong University. While affirming the current results, it also put forward suggestions for improvement in response to some of the current students' feedback. These suggestions are useful to the "Introduction to Biological Microelectronics" and all subsequent courses have their reference significance. The valuable experience of the college's biological microelectronics construction will also provide an effective reference for other colleges and universities to promote the construction of new engineering disciplines and cultivate interdisciplinary talents.

V. Conclusion

In this survey, we found that in accordance with the training plan previously formulated, the introductory course of the first stage can inspire and build students' interest in bio microelectronics to a certain extent, helping students clarify their favorite direction, and help the students choose courses later. At the same time, we also found that the students did not pay enough attention to the degree of participation in the course. So we put forward some suggestions for this problems. In terms of teaching, we recommend paying attention to matching the depth of teaching with the foundation of students, enriching teaching methods, and attaching importance to providing self-study resources after class. Teachers should also control the difficulty and quantity of homework, and increase the proportion of simulation experiments and frontier literature search homework. In the follow-up courses, these measures may help to enhance the students' learning experience and consolidate and expand the teaching results. This survey has accumulated valuable experience in the field of interdisciplinary talent training and for the construction of bio microelectronics and micro majors in our college.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, Jing-Jing Xu; methodology, Ji-Yao Liang and Yu-Xiao Li; validation, Xiao-Fei Xu and Zhao-Gang Dong; investigation, Ji-Yao Liang and Yu-Xiao Li; data curation, Yue-Lin Xing; writing—original draft preparation, Ji-Yao Liang and Yu-Xiao Li; writing—review and editing, Jing-Jing Xu; visualization, Xiao-Fei Xu and Zhao-Gang Dong; supervision, Jing-Jing Xu; project administration, Jing-Jing Xu; funding acquisition, Jing-Jing Xu. All authors have read and agreed to the published version of the manuscript; all authors had approved the final version.

Funding

This work was financially supported by the Education and Teaching Reform Research Project of Shandong University (No. 2019Y166, 2021Z11).

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